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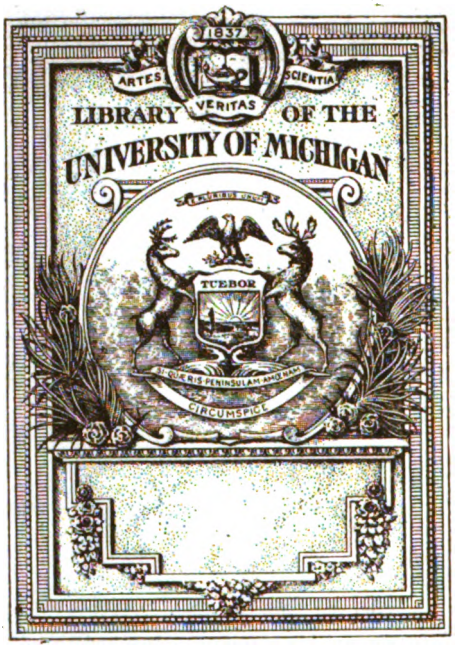

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New Zealand J. of Science	New Zealand Journal of Science and Technology	Single copy, 1s. 6d.; 6s. per annum, post free.	Dominion Museum, Wellington, New Zealand
Optical Soc., Trans.	Transactions of the Optical Society	Price to non-members, 3s., except for supplement	39, Victoria Street, Westminster
Soc. Franç. Elect., Bull.	Bulletin de la Société Française des Electriciens, formerly Bulletin de la Société Internationale des Electriciens	Single copy, 3 fr.; 32 fr. per annum, post free.	Gauthier-Villars et Cie, 55, Quai des Grands-Augustins, Paris
Terrestrial Magnetism	Terrestrial Magnetism and Atmospheric Electricity	Single copy, 90 cents; $3.25 per annum, post free	John Hopkins Press, Baltimore, Maryland, U.S.A., and William Wesley & Son, 28, Essex Street, Strand, London
Wireless Age	Wireless Age	Single copy, 20 cents; $2.48 per annum, post free	Wireless Press, Inc., 25, Elm Street, New York, U.S.A.

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Section B.—ELECTRICAL ENGINEERING.

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PRIME MOVERS.

STEAM PLANT.

1. *Electric Boiler-heating for Steam Locomotives.* **W. Kummer.** (Schweiz. Bauzeitung, 1917. Elektrot. u. Maschinenbau, 35. pp. 484–485, Sept. 9, 1917. Abstract.)—This article suggests that electric boiler-heating offers economic advantages on Swiss steam railways; there are also criticisms by other writers. Kummer considers that electric heating can compete with coal firing for boilers at the present price of coal in Switzerland. Any kind of current may be employed so long as it is transmitted at high enough pressure. The table gives data for three types of Swiss steam railways referred to traffic in ton-km. (total weight):—

	Rhætian Railway.	Gotthard Railway.	Swiss Mountain Railways. Circuits 1 to 4.
1. Coal consumption (kg. per ton-km.)	0·100	0·080	0·075
2. Steam consumption (kg. per ton-km.):—			
(*a*) Using saturated steam	0·700	0·560	0·525
(*b*) Using superheated steam	0·600	0·480	0·450
3. Electrical energy at feeding-point of line (watt-hrs. per ton-km.):—			
(*a*) Steam boiler heating	600	480	450
(*b*) Direct electric drive	48·1	46 to 47	45 to 46
4. Cost of steam (Rappen per ton-km.):—			
(*a*) Coal firing	1·00	0·80	0·75
(*b*) Electric boiler heating (excluding working cost for line, and loco. conversion)	0·90	0·72	0·675

Assuming feed-water at 80° C. the heat expenditure for steam as used on locomotives averages 685 kg. cals. per kg. for saturated steam and 700 kg. cals. per kg. for superheated steam. On the basis of 1 kg. cal. = 1·16 watt-hr., and allowing 86 % efficiency for saturated steam or 81 % for superheated steam between the line feeding-point and the steam raised, we have

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an energy consumption of 857 watt-hrs. per kg. with saturated steam, and 1000 watt-hrs. per kg. with superheated steam. Lines 8 (*a*), (*b*) in the table show the much higher efficiency of direct electric drive, compared with electric heating of steam boilers. Lines 4 (*a*), (*b*) are based on lines (1) and (3), and on coal at 100 fr. per ton and electrical energy at 1·5 Rp. per kw.-hr. Under these conditions, electric heating is 10 % cheaper than coal firing. Allowing 0·048 to 0·055 Rp. per ton-km. for working line costs, and from 0·015 to 0·01 Rp. per ton-km. for the conversion of steam locomotives to electric heating, the cost of electric heating would be practically equal to that of coal firing. Kummer suggests that tests be made on an electric railway with a steam locomotive fitted for electric heating.

L. Thormann criticises the practicability of the proposedsystem. This writer allows 1 kw.-hr. per kg. of steam at working pressure ; and an energy consumption with electric boiler-heating equal to about 10 times that with electric locomotives. If there is a heating surface of 250 m.² already available on the locomotive to be converted, approximately another 650 m.² would have to be provided, with a construction weight of 52 tons. Probably the extra weight of the electrically heated boiler would be 60 to 80 tons, excluding transformers which would probably be necessary and would add another 80 tons to the dead weight. The crucial point seems to be the heating surface required. Thormann's estimate is much higher than Kummer's, owing partly to his assuming that there is no considerable heat storage, so that the heat equivalent of electrical energy supplied would have to correspond to the instantaneous steam demand. Thormann concludes that the weight of an electrically heated boiler and locomotive would be 2 or 8 times that of an ordinary steam locomotive ; the former would be costly and increase materially the specific energy consumption, so that energy would have to be obtainable at 1·5 centimes per kw.-hr. to compete with coal firing. This price, at the line wire, cannot be realised.

In his reply, **Kummer** asserts that 2750 kw. at the line would provide 417 h.p. at the wheel-rim of an electrically heated locomotive, sufficing to propel a total weight of 850 tons at 25 km. per hr. up a 1 : 100 gradient. Thormann's assumption of 917 m.² heating surface for 1086 h.p. (at rim) corresponds to 1·18 h.p. per m.², whereas 4 to 6 h.p. per m.² is commonly obtained with locomotive boilers providing saturated steam, and 6 to 8 h.p. per m.² with superheated steam. Kummer does not agree that the locomotive weight would be much increased by electric heating; as compared with plain electric drive, the electrically heated boiler would be able to accumulate energy during station stops and whilst running downhill.

A. Trautweiler suggests that surplus electrical energy if available free, could be used advantageously to pre-heat feed-water for locomotives up to 90° C. or so in stationary plant at depôts. At a medium-sized depôt 250 m.³ of feed-water might be required daily for 20 locomotives. If 5000 kw. spare capacity be available for 5 hrs. each night at an adjacent power station, this could be utilised (at 80 % efficiency) to warm the 250 m³. of feed-water through 70° C. This would correspond to a saving of 8000 kg. coal per diem. Even on the basis of peace prices for coal, this saving would cover the costs and charges on the pre-heating equipment. R. E. N.

2. *Flexibility of Boiler Control.* **V. B. Phillips.** (El. World, 70. pp. 761–768, Oct. 20, 1917.)—Directs attention to the nearly equal importance of reducing fixed charges and labour, forming 40 % of the cost of steam production, and of increasing the efficiency to reduce fuel cost, which is

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50 % of steam production cost. Uniformity of efficiency over a wide range of loads is a characteristic of modern turbines and the same is required for boilers; the difficulty in obtaining this, however, lies in the furnace. The regulation of the time for complete combustion is inflexible in many automatic stokers because the grate area is fixed. This inflexibility must be compensated for by varying the air supply, which should be independently regulated to the several parts of the furnace. Nine tests were made for the Cleveland Railway Co. on a Taylor six-retort stoker with extension grate under a 512-h.p. Babcock and Wilcox boiler. The tests were made with three different fuel-bed thicknesses at three different loadings. The results are plotted in curves between percentage furnace efficiency and heat output in boiler-h.p. The best results in connection with sustained overloads were obtained when a comparatively light fuel bed was used. The bed was easier to maintain in good and uniform condition when it was thin. W. N. Y. K.

3. *Heat-transfer between Flowing Gas and containing Flue.* **L. H. Fry.** (Am. Soc. Mech. Eng., J. 39. pp. 843–849, Oct., 1917.)—The author offers a formula which represents the processes of heat-transfer between a gas and a metal flue-wall, within a wide range of conditions sufficiently accurately for practical purposes. This formula is based on experiments with products of combustion, lighting gas, CO, and air, all at atmospheric pressure; also air at pressures from 0·15 to 140 lbs. per sq. in. abs.; for rates of flow from 0·5 to 650 lbs. per hr.; for flues of annular and circular cross-section (effective diams. 0·5 to 2 in., lengths 0·64 to 20 ft.); and with inlet gas temperatures from 2340° F. (products of combustion, being cooled) to 55° F. (air being warmed). The formula applies equally to hot gas and cooler flue, and to cool gas and hotter flue; although established by empirical methods it probably represents closely the fundamental law of heat-transfer under these conditions. If gas flows at W lbs. per hr. through a flue of hydraulic depth $d/4$, and if the abs. temperature of the gas be T_1, T_2 at the beginning and end of a length x ft. in the direction of flow, and t be the mean flue temperature in this section, then: $\log T_1/t - \log T_2/t = M$...(1); if the gas be hotter than the flue. If the flue be the hotter, the fractions in this formula are inverted. M is a constant depending only on W and $d/4$. In the present experiments, the value of M, above a critical rate of flow of 5 lbs. per hr., is given by: $\log M = A - m \log W$...(2); where $A = 1{\cdot}558 - 0{\cdot}185d$....(3), and $m = 0{\cdot}14 + 0{\cdot}083d$....(4). The author points out that equation (1) is a general relation, and shows how M (measuring the slope of the lolog line) is affected by the rate of flow of the gas and by the flue diameter. It should be noted that M depends on the hydraulic depth of the flue (*i.e.* area/perimeter). The "effective diameter" defined as 4 × hydraulic depth is the same as the actual diam. in a flue of circular cross-section.

The data from which the above equations are derived are from 205 experiments covering a very wide range of conditions and falling into six groups due respectively to Jordan (air); Nusselt (air, CO_2, and lighting gas); Babcock and Wilcox Co. (products of combustion); Fessenden (products of combustion); Josse (air); and the Pennsylvania R.R. (products of combustion). The Jordan experiments are among the most accurate and have played a considerable part in establishing the formulæ. Two of the flues used were annular and three circular, the effective diam. ranging from 0·506 to 1·968 in. The flow ranged from 80 to 620 lbs. air per hr. and the inlet temperature from 288° to 750° F. Inlet and outlet temperatures were measured for air passing through a vertical flue 1 m. long and surrounded

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by cooling water flowing in the opposite direction. Particulars of the other experiments and leading data for all are given in the original. The process of studying the validity of equation (1) and of arriving at the law expressed by equations (2), (3), (4) is described fully.

An increase in the coefficient M means more rapid interchange of heat between flue wall and gas. As the rate of flow increases the value of M decreases, *i.e.* there is less change in temperature of the gas between any two points. In a particular case, gas flowing at 10 lbs. per hr. was raised 85·5 deg. C. out of a possible 42 deg., the heat-transfer being at the rate of 84·6 B.Th.U. per hr. At 500 lbs. per hr., the temperature-rise was only 16 deg. C., but the heat-transfer was 1910 B.Th.U. per hr.

Equation (2) is universally applicable if values of A and *m* be chosen to suit each flue. The formulæ proposed agree with the actual results of at least five other sets of experiments within the limits of experimental error. There is good reason to believe them to be generally applicable.

A mental picture of the mechanism of heat-transfer between gas and flue wall is suggested and explained. Particles and gas bombard the flue walls repeatedly and at each contact they acquire the flue temperature. During approach and on the rebound, the particles collide with others; hence particles nearing the flue approach its temperature before contact, and particles leaving the flue wall tend to revert to the centre temperature. There is a film of gas at wall temperature close to the flue, but the more rapid heat-transfer at higher gas speed is not due to the wall-film being swept away, but to the greater number of particles introduced to bombard the wall. Though the rate of heat-transmission may be increased, the efficiency of the process is reduced: this distinction is important. Fitting a core to the flue, reduces the mean hydraulic depth and results in greater number of hits in given time; hence more heat is transferred.

Measuring the equivalent mean temperature of gas on a given section of the flue is not easy; a Pt-resistance thermometer distributed over the section is fairly successful. Heat-transfer involves loss of head by any fluid passing through a flue; the law is imperfectly established but it is suggested that a general formula of the type given for heat-transfer might be worked out for loss of head. Beyond a certain point, loss of head makes unremunerative the gain in heat-transfer. R. E. N.

4. *Utilisation of Low-grade Fuels.* (El. World, 70. pp. 898–900, Nov. 10, 1917.)—Gives briefly the results of experience of the use of low-grade fuels in various types of furnace and mechanical stoking plant.

American Engineering Co.—The best results have been obtained with by-product breeze, in spite of lower calorific value and higher moisture content than any other form of breeze. Lignite of calorific value 6500 to 9000 B.Th.U. is being largely burned with efficiency.

Bessemer Coal and Coke Co., Russelltown, Pa.—Bone coal, with 36 to 49 % ash content, and calorific value 8000 to 9000 B.Th.U. is being successfully burnt without modification of stokers formerly used for coal.

Various railway and other companies give brief reports on the use of low-grade fuel. W. N. Y. K.

5. *Burning Low-grade Fuels with Existing Equipment.* R. J. S. Pigott. (El. World, 70. pp. 429–432, Sept. 1, 1917.)—Problems involved in burning high-ash coals are discussed, and the results of the use of stokers with high- and low-grade fuels are compared. Coal having 10,000 B.Th.U. calorific value requires about 45 % more grate surface to obtain the same max. output

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from the boiler than does coal of 14,500 B.Th.U. per lb. Very little difference in the amount or pressure of blast air is needed with various kinds of coal for the same output. The quantities of air required by various fuels (data obtained from Edge-Moor boiler) are tabulated.

	Air/Fuel.	Air/Combustible.	Air/10,000 B.Th.U. in Fuel.
	Lbs.	Lbs.	Lbs.
North Dakota lignite	5·0	9·2	7·54
Colorado lignite	7·5	9·9	7·58
Illinois bituminous	8·4	10·8	7·66
Ohio bituminous	9·7	11·2	7·68
Pennsylvania bituminous	10·8	11·8	7·50
Pennsylvania semi-bituminous	10·8	12·0	7·65
West Virginia semi-bituminous	11·2	12·1	7·65
Pennsylvania anthracite	9·6	11·9	7·66
California crude oil	14·1	14·2	7·59
Average	—	—	7·60

The most important causes of variation in blast pressure are the handling of the fire, depth of fuel-bed, and holes in the fire. The efficiency of stoking is lowered by the use of low-grade fuel, apparently about 1 % for every 1000 B.Th.U. per lb. reduction in the calorific value. The volume of coal in the fire largely affects efficiency, a certain depth being essential to the proper mixing of air and volatile matter. For boilers to be forced to a very high output as much retort capacity as possible is required, and smokelessness will depend largely on the depth of the retort. The best results for very low-grade fuels are obtained with furnace volume, about 9 cub. ft. per sq. ft. projected grate area. Different classes of grate and also details of equipment are discussed. The presence of sulphur and a high ash content give trouble by forming a fusible flux with brickwork. High-refractory brick, bauxite, or carborundum has been tried to a limited extent to reduce maintenance; also conditions are greatly improved by wall ventilation by air and steam: one method for this is illustrated. W. N. Y. K.

6. *Low-temperature Carbonising and some of its Products.* **R. Maclaurin.** (Soc. Chem. Ind. J. 36. pp. 620–626, June 30, 1917. Engineering, 104. pp. 159–161, Aug. 10, 1917.)—An account of the trials carried out with a small experimental gas plant erected at the Port Dundas Station of the Glasgow Electricity Committee. The plant was designed by the author for two purposes: (1) the production of a smokeless-fuel and illuminating-gas, and (2) the production of power-gas, with recovery of light oils and ammonia in both cases.

Power-gas.—For the production of power-gas, air and steam were blown into compartment A, and the gas passed up through the fuel, carbonising it and distilling-off the oils. The heavier oils condensed and ran down to the collar, where they were trapped and overflowed along the pipe to the seal-tank. Here the heavier oils were left, and the gases ascended through the first scrubber, where they met a very fine spray of water, containing about ½ % of free sulphuric acid; from this they entered the second scrubber, in which they were intended to be treated with a shower of heavy oil, to abstract the lighter oils, though this was never put into use. From this

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scrubber they were drawn by a Sirocco fan, and passed to burners, where they were burnt under a water-tube boiler. The following is a typical analysis of the power-gas made : CO_2, 12·9 ; O_2, 0·9 ; C_nH_{2n}, 0·2 ; CO, 5·6 ; CH_4, 10·0 ; H_2, 8·9 ; N_2, 61·5 %. Calculated heating-value = 184 B.Th.U. per cub. ft.

Smokeless Fuel.—The manufacture of smokeless fuel, contrary to expectation, worked smoothly. The fuel came down regularly and was thoroughly carbonised. No matter the size of the coal used, it was always uniformly coked from outside to centre. Working for smokeless fuel, the author anticipated getting from 10 to 12 cwt. per ton of coal, about 10,000 cub. ft. of gas of about 550 B.Th.U., from 15 to 25 galls. of oil, and a yield of ammonia at least equal to gas-works practice. The estimate for the coke was made on the assumption that about 2 cwt. of the coal would require to be burned to ash, to carbonise 1 ton of coal. To prevent this ash being mixed with the smokeless fuel the furnace was made with two compartments. The coal was to be carbonised in compartment A, and the hot power-gas was to be made in compartment B. Three coals have been coked in the producer so far, these are Tannochside cannel, Cadder coking coal, and Greenhill coking coal. The analysis of the coals and the dried coke is shown in the accompanying Table, and for comparison there is shown alongside an analysis of gas-works coke, obtained at the high temperature of a horizontal retort.

	Water, %.	Volatile Matter, %.	Carbon, %.	Ash, %.
Cannel coal	10·70	80·72	46·51	12·17
Residue from same.....	—	—	—	18·00
Cadder coking coal.....	10·40	82·97	50·44	6·19
Dried smokeless fuel from same	—	4·77	86·71	8·52
Greenhill coal	12·69	88·09	50·68	8·85
Dried smokeless fuel from same	—	8·9	—	—
Coke from horizontal retorts	—	4·80	86·40	9·80

J. B. C. K.

GAS, OIL, AND WATER ENGINES.

7. *Properties of Motor-petrol, with Methods of Testing and Specifications for same.* **E. W. Dean.** (Bureau of Mines, Techn. Paper No. 166. [23 pp.], Washington, 1917.)—The essentially desirable properties of petrol are summarised under five heads. After discussing each of these properties in detail and their relation to the ordinary methods of testing petrol, the author sketches a proposed specification for a motor-petrol as follows :—

Colour.—Requirement : Water white. *Method of determination* : Inspection of column of petrol in a 4-oz. sample bottle. *Acidity.—Requirement* : Total absence. *Method of determination* : Ten cm.^{3} of the petrol is to be shaken thoroughly with 5 cm.^{3} of distilled water. The aqueous extract must not colour blue litmus paper pink. *Volatility.—Requirements* : The petrol when distilled by the method described hereafter shall meet the following conditions : (*a*) The temperature read on the thermometer when 20 % has distilled

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shall not be below 70° C. (158° F.) nor above whatever limit is fixed. (*b*) The temperature read when 90 % is distilled shall not be above another limit similarly chosen. (*c*) The temperature read when 50 % has distilled shall not be higher than a mark half-way between the 20 % and the 90 % limit. (*d*) The dry point shall not exceed the actual 90 % reading by more than 55 deg. C. (99 deg. F.). *Tolerance*: If either the 20 % or the 90 % temperature mark be above the required limit by an amount not exceeding 10 deg. C. (18 deg. F.), the petrol may be considered acceptable if the sum of the two temperatures read for the 20 % and the 90 % marks does not exceed the sum of the adopted limits.

The method of and apparatus for distillation are finally discussed, and the outlines are given of a standard method with a detailed specification of the flask, thermometer, and condenser to be used. J. B. C. K.

8. *Pitting and Design of Water Turbines.* **S. J. Zowski.** (West. Soc. Eng., J. 22. pp. 276–296; Disc., 296–297, April, 1917.)—The designer of a turbine can do much towards eliminating local corrosion of turbine parts. The electrolytic theory of corrosion is very satisfactory, but whether this be adopted or not, oxygen dissolved in the water plays the most important part in the corrosion phenomenon. The composition of the atmosphere and the solubility of its components are such that 24·72 cub. ft. of air are dissolved per 1000 cub. ft. of water at 0° C. and 760 mm. The oxygen content of this air is 34·97 % (by volume), *i.e.* the air absorbed by water is richer in oxygen than that of the atmosphere. If the water pressure falls to ½ atmo. (that is a vacuum of 17 ft. water column) half the air contained at atmospheric pressure is liberated. General de-aeration throughout the body of the stream does no particular harm, but if the liberated air comes in contact with the metal at particular points, corrosion is there severe and amounts to pitting.

Cavitation often occurs at points where the curvature of turbine runner buckets is too sharp for the water stream to follow. A partial vacuum results at least locally, and intense local corrosion is caused by the oxygen liberated. Small bucket angle β is often used for the sake of lower peripheral velocity, *i.e.* to counteract the effect of high head upon the turbine speed. Cavitation can hardly be prevented if β be small, hence pitting at the bend of the bucket is difficult to avoid in high-head turbines. With small values of β the pressure at runner-entry decreases, so that de-aeration is very liable to occur there as well. The author gives an analytical and graphical treatment of the pressure conditions at entry for turbines running under 25, 100, 250, and 500 ft. head, with suction head of 20 ft. in the last three cases and 10 ft. in the first case. The simple rule that pressure at runner-entry disappears when $\beta = 2\alpha$ is not sufficient safeguard against obtaining negative pressure, particularly where the suction head is relatively large.

In low-head turbines the suction head has the greatest effect on the pressure conditions. There are cases where the pressure will be negative however large β be made. Only in high-head turbines, where the suction head is relatively small is the effect upon the pressure conditions or the critical values of $\beta : \alpha$ almost negligible. There is, in addition, the effect of the sudden enlargement at the guide-vane tips, which is important in high-head turbines but not in low-head turbines. The pressure drop in the eddies just beyond the guide-vane tips may be calculated accurately enough for practical purposes; formulæ are given in the original.

Runner buckets are attacked at other points as well, where the damage is traceable not to pressure conditions at entry, but to a throttling effect in

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the passage, caused either by faulty design or errors in construction. Trouble from this cause is most likely to occur in high-head turbines, which are generally cast in one piece and are liable to small but serious errors in construction. Long parallel bucket ends are not to be recommended; a certain degree of nozzle effect is preferable from the point of view of efficiency as well as that of less pitting.

The means whereby the designer may reduce pitting to a minimum are as follows:—Avoid small β altogether in high-head turbines and do not use very large angles α. Do not place the turbine higher than necessary above tail-race. Use the largest possible angles β when designing low-head runners which may have to be applied to different conditions. Introduce slight nozzle effect so as to accelerate flow throughout the buckets and guide-vanes. Point the guide- and bucket-vane tips to make the eddies short; make the guide-vane ends as thin as possible. Place the guide vanes so far from the runner that the streams join into a ring before entering the runner. Avoid sharp turns, depressions, and throttling effect. See that in no position of the guide-vanes is the opening smaller than at the discharge point.

R. E. N.

9. *Transatlantic Flight.* **A. v. Parseval.** (Zeits. Vereines Deutsch. Ing. 61. pp. 784–785, Sept. 1, 1917.)—A consideration of the possibilities of commercial transatlantic flights from Germany to America *via* the Azores by means of dirigibles. The author concludes that the mechanical and engineering difficulties are not insuperable. J. W. T. W.

10. *Development and Progress in Aviation Engines.* **H. Souther.** (Frank. Inst., J. 184. pp. 509–526, Oct., 1917.)—The author describes some of the more striking developments in aeroplane construction which have taken place in the last few years. He points out the extremely exacting working conditions of an aeroplane engine, and contrasts the first Wright engine of 12 h.p., weighing less than 200 lbs., with the present-day engines of 250 h.p. and more. Stress is laid throughout on the fact that in aeroplane construction quality (*i.e.* safety) comes first and cost last. The paper is illustrated throughout with photographs of machines and engines. J. W. T. W.

11. *Limits in Aeroplane Performance.* **A. R. Low.** (Engineering, 104. pp. 475–476, Nov. 2, 1917. Abstract from Aeronautical J. 21, pp. 40–46, Jan.–March, 1917.)—Gives curves from which, given the most effective relation (as estimated by the useful load carried) between power, wing-surface and speed, for some one value of the useful load, the optimum relation between these quantities at any other useful load can be at once determined for a machine of the same type. An isolated central point of the diagram represents the conditions corresponding to the max. possible load. This can be carried only at one speed and with one power. If the power be increased beyond this value, the consequent increase in engine weight will diminish the possible useful load carried. A second diagram shows the limit of useful weight carried at various heights, *i.e.* the "ceiling heights" of the machines with different weights on board. J. W. T. W.

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PROPERTIES OF ENGINEERING MATERIALS.

12. *Transverse Fissures in Steel Rails.* **J. E. Howard.** (Am. Inst. Mining Eng., Bull. No. 131. pp. 1871–1882, Nov., 1917.)—Transverse fissure is a term applied to a special type of fatigue fracture occurring in a rail in which the metal next the running surface of the head of the rail is in a state of internal compression. By the fatigue of metals is meant the effect produced by oft-repeated strains. Tests have shown the limiting value for steels to be about 40,000 lbs. per sq. in. for practically unlimited endurance of repeated alternate stresses. Steel rails in the track are subjected to bending stresses, the magnitude of which depends primarily upon the amount of the wheel loads and the number of repetitions within a given interval of time. There are internal strains in rails which result from the conditions of manufacture or which are acquired after the rails have reached the track; these are dealt with in the paper. Examination has shown transverse fissures to have their origin in metal microscopically sound and normal in structure. C. O. B.

13. *Embrittling of Steel by Sodium Hydroxide.* **S. W. Parr.** (Univ. of Illinois, Bull. No. 94. [57 pp.] Jan., 1917.)—The water of Urbana, used since 1887, contains a peculiar mixture of carbonates or bicarbonates, 60 parts per million of sodium with 400 parts of calcium, magnesium, iron carbonates. In boilers of recent installation peculiar cracks develop between rivet-holes and outward from these holes, always in connection with leakage and below the water-line, but accompanied by an exterior accumulation of strong alkaline reaction; the water in these cases contains NaOH.

The investigations by the author with Hirschkind and Merica concern the potential and strength of steel wires under different conditions. The wires were annealed at 700° C. in 0·1 normal KOH; they gave about 0·82 volt against the calomel electrode, the potential slowly decreasing as the iron turned passive; in the dilute sulphuric acid the potential was higher and changed more slowly. This difference is attributed to the circumstance that the iron takes up hydrogen ions from the acid and assumes a higher potential. The wires were then heated up to 110° or 120° for one week in caustic soda of 10, 25, 50, 70 %, the stronger solutions of which made the wires rough. The heated wires showed higher potentials than the unheated (*e.g.* 0·48 against 0·87 volt), and their breaking strength was lowered, whilst the elongation was slightly increased by the treatment. Alternating bending and impact tests were also made. In some tests the temperature was raised to 280°, and strong evolution of hydrogen was noticed; the brittleness then increased for a week or so, and then decreased again, the material recovering its strength. Some comparative tests of wires under tensile stress and not under stress were inconclusive. There was no distinct connection, moreover, between the high potential, which slowly disappeared with time or on heating, and the brittleness; the potential-rise occurred long before the brittleness manifested itself. The author believes, however, that the embrittling action is due to the absorption of hydrogen ions. The alkalinity of the boiler water has experimentally been neutralised with magnesium sulphate or sulphuric acid; the addition of sodium dichromate lowered the potential, but produced an incrustation containing chromic hydrate in the boiler. H. B.

14. *Acid-proof Nickel-Copper-Tungsten-Iron Alloys.* **R. Irmann.** (Metall u. Erz. 14. pp. 21–30, and 37–42, 1917. Engineering, 104. p. 610, Dec. 7,

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1917. Abstract.)—Looking for an alloy which would not be attacked by sulphuric acid, the author found that the Ni was dissolved from Ni-Cu alloys and that the electrolytic corrosion of voltaic couples of the two metals did not afford any clue, as is sometimes assumed, as to the corrosion of alloys of the two metals. An alloy of Ni with 20 % of tungsten resisted sulphuric acid, but was difficult to machine. He then prepared alloys of Ni or Cu with W in electric furnaces. Of the Cu-W alloys that with 4·98 % W proved very resistant to acid and very strong, giving also high elongation : the electric resistance was higher than that of constantan. Very good results were also obtained with several ternary Ni-Cu-W alloys. These results were further improved by adding iron to the alloys, so that technically ferro-tungsten could serve as material. With increasing Fe content (up to 4 %), the resistance to acid and the strength increased. For hot concentrated acid a quaternary alloy with 43·65 Cu, 8·7 W, and 1·87 Fe seemed best ; this alloy was strong, could be machined, and had a high electric resistance. For cold acid, alloys should be rich in Cu and relatively so also in W and Fe. Some of the alloys, however, tended to separate in layers. Attempts to improve German silver by the addition of W failed ; Zn and W would not alloy, and all the quaternary Cu-Ni-Zn-W alloys were attacked by acid.

H. B.

15. *Alignment Diagrams for determining the Bending Moments of Reinforced Concrete Beams.* (Engineering, 104. pp. 242–244, Sept. 7, 1917.)—The diagrams (which are reproduced to a large scale) were drawn by E. P. Watson and G. L. Wingfield, of the Egyptian Public Works Ministry, and are graphical representations of the formulæ for reinforced concrete beams given in the London County Council regulations. The upper diagram shows the relation between the bending moments and the working stresses of rectangular beams, and the lower, which is really a pair of separate diagrams, supplies the same information for T-beams. The method of using the diagram is extremely simple. In all calculations for the designing or checking of rectangular reinforced concrete beams the values t, c, $B \div bd^2$, and r occur, two of these values being known or assumed, and the other two required. A straight line drawn through the known values on any two of the scales will intersect the other two scales at points corresponding to the two required values.

W. J. C.

16. *Refractory Properties of Magnesia.* **H. le Chatelier and B. Bogitch.** (Comptes Rendus, 165. pp. 488–491, Oct. 15, 1917.)—Though pure magnesia melts at about 2400°, commercial magnesia softens at a considerably lower temperature owing to the impurities, spathic iron, silica, alumina, etc. Attempts to prepare in the laboratory a block of pure magnesia by fusing precipitated magnesia in an electric furnace were only partly successful because the lime of the furnace walls was volatilised and contaminated the product. Seven bricks were submitted to the same strength tests as the silica bricks [see Abs. 767 (1917)]. The brick E from Eubœa contained 98·4 % MgO, a brick S from Styria 86·7 %. In all cases the strength dropped rapidly almost to zero at a certain temperature, the E brick from about 420 kg./cm.^{2} (at 0°) to very low values between 1500° and 1600°, the S brick from 150 kg./cm.^{2}, between 1300° and 1400° ; the bricks softened as if the grains of magnesia were floating in the fused impurities. At 1600° the best magnesia bricks are much inferior to silica bricks ; hence their unsuitability for furnace arches. A chrome-iron brick (50 % Cr_2O_3, 15·5 FeO, 12·8 MgO, 10·9 alumina, 5·8 CaO, 4·7 SiO_2, 1·5 Mn_2O_3) lost its strength already at 1100°,

 H. B

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17. *Potash from Felspar.* **J. C. W. Frazer, W. W. Holland,** and **E. Miller.** (Ind. and Eng. Chem., J. 9. 10. pp. 985–986, Oct. 1, 1917. Engineering, 104. p. 582, Nov. 30, 1917. Abstract of paper read before the Am. Inst. Chem. Eng., June, 1917.)—The authors convert orthoclase into an artificial leucite which can be decomposed by hydrochloric acid; the conversion is effected by means of caustic potash, which, however, is recovered. Heating the felspar with caustic potash to 300°, they obtain $KAlSi_2O$ and K_2SiO_3; the latter potassium silicate is filtered off from the leucite and is decomposed with lime to regain the potash. The leucite is decomposed with just sufficient HCl to bind the K, the KCl being filtered off; the remaining aluminium silicate is decomposed with sulphuric acid, when silica (gelatinised by heating) and aluminium sulphate result. H. B.

18. *Coal Distillation under Pressure.* **J. H. Capps** and **G. A. Hulett.** (Ind. and Eng. Chem., J. 9. pp. 927–935, Oct. 1, 1917. Engineering, 104. pp. 610–611, Dec. 7, 1917. Abstract.) Experiments on a small scale with 4 kinds of coal, heated in a steel retort up to 600° C. and 20 atmos. in a tubular electric furnace. The retort had a capacity of 1·9 litres and resembled a vertical mercury thermometer with long bulb into the stem of which a cooling tube was inserted axially. The vapours were condensed in a trap condenser, a cylinder, the vertical axis of which was taken up by a cooling tube, and further condensed in a second vessel; part of the stem of the retort and the first condenser were provided with a jacket which was electrically heated to keep low-boiling vapours out of the first condenser. As the pressure was increased the yield of heavy hydrocarbons, and especially also of phenols and acid products, decreased, while up to 5 % more light oils were obtained. More coke was produced, this coke being of superior calorific value; there was also more gas at higher pressures and temperatures: up to 500° the gas was chiefly hydrogen; above 550° the hydrogen percentage decreased again, probably because the hydrogen reacted with the N, O, S and some of the compounds. H. B.

19. *Study of Surface Resistance with Glass as Transmission Medium.* **H. R. Hammond** and **C. W. Holmberg.** (Am. Soc. Mech. Eng., J. 39. pp. 849–852, Oct., 1917.)—The majority of heat transmission coefficients are combined coefficients in which no attempt is made to discriminate between the conduction of the material itself and of the two air-spaces adjacent to it. In order to obtain data concerning surface resistance with glass as the transmission medium, the authors study temperature gradients under various temperature differences between inside and outside of the box; the relative values of conduction for the glass and air surface: and the variation in conduction with a temperature-difference between inside and outside of box. Transmission by conduction is alone considered; the B.Th.U. transmitted per hr. $= Q = kA.\Delta T$; where k = B.Th.U. per sq. ft. per hr. per 1 deg. F., A = surface (sq. ft.), ΔT = temperature difference (deg. F.). The value of k depends on the surfaces, the thickness and kind of material, air spaces, the absolute temperature, the temperature difference, and the condition of the air at the surfaces.

The authors investigated experimentally the temperature gradient at various distances from the inside and outside of a glass window in a special corkboard box provided with electric heating coil, circulating fan, and resistance thermometers on each surface of the glass and at various distances up to 28 in. from the glass. The test box etc. was located in a constant-

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temperature room and elaborate precautions were taken to secure reliable results. The curve of inside temperature gradient bent down sharply within the first ½ in.; the curves then grew flatter and became constant at ½ in. from the glass surface. The outside gradients were more gradual, most of the drop occurring in the first 2 in. from the glass in still air and within the first 1 in. under moving air conditions. The results indicate that circulating air inside the test box reduces the air-resistance film at the glass surface and increases conduction of the air layer. Under still air conditions the outside surface resistance was much greater than with moving air, due to much heat being carried away by convection. The resistance is greatest very close to the surface of the glass, and when performing experiments in heat transmission it is best to place the outside thermometer not less than 2 in. from the surface under still air conditions, and not less than 1 in. when the air velocity exceeds 800 ft. per min. Thermo-couples are preferable to resistance thermometers in that they are less susceptible to radiation.

The principal results obtained are as follows:—(1) The gradient tests show that most of the air-layer resistance occurs at the ouside and within the first ½ in. of the surface. (2) Whenever glass or any other good conductor is used as the transmission medium the resistances of the two air surfaces play the major part in determining the combined transmission coefficient. There seems to be a saturation point at which transmission through the air layer cannot be increased. (3) Transmission through glass and through corkboard with temperature-differences of from 20 deg. to 80 deg. F. varies linearly with the latter. R. E. N.

20. *On Water-hammer.* **C. Camichel, D. Eydoux,** and **M. Gariel.** (Comptes Rendus, 165. pp. 548–551, Oct. 22, 1917.)—This paper is a further extension of previous work on water-hammer. The phenomena admit of dual division, viz.: into waves which are propagated with a finite velocity, and bulk oscillations. The first class is produced in pipes entirely air-free, the second in pipes furnished with air entry. The pipes may be classified into those having a characteristic constant, for which the constitution is the same throughout the length, and the ordinary industrial pipes having characteristic variables. The descriptions and conclusions drawn from experiments on pipes made of sheet steel and without air entry include:—(1) Experimental methods; (2) Velocity of wave propagation. (3) Variations of pressure produced in the neighbourhood of the distributor by closures and openings; (4) Transmission of water-hammer along the pipe; (5) Influence of loss of change; (6) Resonance phenomena. The experimental methods are described in detail. With respect to wave propagation it has been fortunately found that the deformation of the wave is sufficiently slight for assuming as a first approximation that the velocity of propagation possesses a definite value which is a function of the diam. and depth of the pipe, and of a coefficient depending on the method employed. A comparison table is given of laboratory and works experience.

H. H. Ho.

21. *Influence of the Variation in Width of the Walls of a Pressure Pipe upon the Water-hammer.* **de Sparre.** (Comptes Rendus, 165. pp. 583–586, Oct. 22, 1917.)—In a pipe whose walls are a constant distance apart, if a closure be made in a period of time less than $2L/a$, where L is the length of the pipe and a the velocity of propagation, the water-hammer is $a V_0/g$, V_0 being the current velocity, and g the value of the acceleration due to gravity. If a pipe be considered where the distance between the walls, and in conse-

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quence the speed of propagation, diminishes from the distributor to the water exit, it might be supposed that the max. water-hammer can only diminish from the latter fact. The effect, however, may be very appreciable and the various conditions are shown mathematically in the paper. It is found that the diminution of width from the upper part of the pipe may, in the case of abrupt closure, increase very considerably the max. water-hammer. On the other hand, in a pipe of constant width, the max. water-hammer is transmitted integrally throughout the pipe for an abrupt closure. In a pipe of variable cross-section the max. water-hammer may be diminished very considerably, even in the case of abrupt closure, according to the distance from the distributor. H. H. Ho.

22. *Effect of Mouthpieces on the Flow of Water through a Submerged Short Pipe.* **F. B. Seely.** (Univ. of Illinois, Eng. Experiment Station, Bull. No. 96 [49 pp.], April 30, 1917.)—This bulletin presents the results of experiments on the flow of water through a submerged short pipe provided with, and also without, entrance and discharge mouthpieces of a variety of angles and lengths. It treats of the loss of head which occurs when a stream contracts or expands under differing conditions of flow, and emphasises the marked effect that turbulence of flow may have upon the amount of head lost. The discussions have a direct bearing upon various problems in hydraulic practice which involve the contraction and expansion of a stream in flowing through passages. Comparatively little experimental work has been done to determine the value of conical mouthpieces of various angles and lengths in reducing the lost head at the entrance to and discharge from a submerged pipe, particularly for mouthpieces of the sizes and proportions comparable with those met with in engineering practice. Generally there is but little definite knowledge on the whole subject of the effect of abnormal conditions, and it offers a large scope for investigation. The flow of water usual in engineering practice is more or less turbulent, while the general equation of energy, or Bernoulli's theorem, only applies when the particles of water move with uniform velocity in parallel stream-lines, and therefore satisfactory analysis require the use of an average velocity and the introduction of empirical constants, hereby involving danger in extending the use of experimental data or empirical constants to apply to conditions of flow quite different from those under which the data were obtained. The apparatus and methods of experimenting receive detailed description, accompanied by several accurate diagrams. The part dealing with the experimental results and their discussion is subdivided into ten sections as follows: (1) A brief analysis of the flow; (2) a set of comprehensive tables and figures; (3) the values of the coefficients of discharge for the short pipe with inward-projecting and flush entrance; (4) entrance mouthpieces; (5) a description of earlier experiments with entrance mouthpieces; (6) discharge mouthpieces; (7) earlier experiments with discharge mouthpieces; (8) combination of mouthpieces and effect of smooth flow; (9) a brief description of the experimental difficulties encountered and methods adopted for their solution; (10) conclusions. The following seem conclusions to be justified:—(*a*) As applying to conditions likely to be met in engineering practice, the value for the head lost at the entrance to an inward-projecting pipe (*i.e.* without entrance mouthpiece and not flush with wall of the reservoir) is 0·62 of the velocity head in the pipe ($0{\cdot}62\ v^2/2g$) instead of $0{\cdot}98\ v^2/2g$, as usually assumed. In another form, the coefficient of discharge for a submerged short pipe with an inward-projecting entrance is 0·785 instead of 0·72 as given in nearly all books

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on hydraulics ; with a flush entrance the value is 0·80 instead of 0·82 as given by nearly all authorities. (*b*) The loss of head resulting from the flow of water through a submerged short pipe when a conical mouthpiece is attached to the entrance end, may be as low as 0·165 of the velocity head in the pipe ($0{\cdot}165\ v^2/2g$) if the mouthpiece has a total angle of convergence between 80° and 60°, and an area of ratio of end sections between 1 to 2 and 1 to 4 or somewhat greater ; *i.e.* the coefficient of discharge is 0·915. (*c*) The loss of head for any mouthpiece whose total angle of convergence is between 20° and 90°, and whose area ratio is between 1 to 2 and 1 to 4 or somewhat more, is approximately 0·20 of the velocity head in the pipe ($0{\cdot}20\ v^2/2g$). There is, therefore, little advantage to be gained by making an entrance mouthpiece longer than that corresponding to an area ratio of 1 to 2 (*d*). The amount of velocity head recovered by a conical mouthpiece when attached to the discharge end of a submerged short pipe, depends largely upon the angle of divergence of the mouthpiece, but comparatively little upon the length of the mouthpiece. This is true for lengths greater than that corresponding to an area ratio of 1 to 2, and for total angles of divergence of 10° or more. The amount of velocity head recovered decreases rather rapidly as the angle of divergence increases from a total angle of 10° to 40°. At or near 40° the amount of velocity head recovered falls rather abruptly to approximately zero. (*e*) A conical discharge mouthpiece having a total angle of divergence of 10° and an area ratio of 1 to 2, when attached to a submerged short pipe, will recover 0·485 of the velocity head in the pipe, which is 58 % of the theoretical amount possible of recovery. (*f*) The amount of velocity head recovered by a diverging or discharge mouthpiece when attached to a submerged short pipe, is considerably more when a converging or entrance mouthpiece is also attached, than it is when the entrance end of the short pipe is simply inward-projecting (no mouthpiece attached). This excess in the velocity head recovered, diminishes rather rapidly as the angle of the discharge mouthpiece increases, and becomes zero for a discharge mouthpiece having a total angle of divergence of approximately 40°. This increase in the velocity head recovered is probably due to the effect of smooth flow in the pipe as the water approaches the discharge mouthpiece. The smooth flow allows the mouthpiece to recover more of the velocity head in the pipe than when a more turbulent flow exists ; this increase amounts to as much as 33 % in the case of the discharge mouthpiece having a total angle of divergence of 10° and an area ratio of 1 to 2.

The author feels that the results of the experiments are applicable in a general way to a large variety of cases in engineering practice where the contraction and expansion of a stream of water occurs, *e.g.* the intake to a pipe, particularly when the pipe is of short length and large diam. ; the suction and discharge pipes of a low head pump ; the reduction or expansion from one pipe to another of different diam. or of different shape ; the passages through a large valve ; the passages through locomotive water columns ; the draught tube to a turbine ; the connection from a centrifugal pump to a main ; the sluice-ways through dams ; the slot screens at head gates, culverts, and short tunnels ; jet pumps ; the Boyden diffuser as formerly used for the outward flow turbine ; the Venturi meter ; the suction and discharge pipes of dredges ; and the guide-vanes and runner of a turbine. H. H. Ho.

23. *Benzol Recovery : Laboratory Methods of Control.* **F. W. Sperr.** (Met. and Chem. Eng. 17. pp. 548–555, Nov. 1, 1917.)—The chief chemist of the

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Koppers Coke Oven Co. describes in this article the operation of the benzol-recovery plant in the Koppers system of by-product coke-oven working, and also the laboratory methods which he has found most useful in controlling the work of this portion of the plant. The article is illustrated, and contains detailed descriptions of the tests employed. J. B. C. K.

24. *Air-lift Pumping.* **A. W. Purchas.** (Inst. Mech. Eng., J. No. 8. pp. 613–650, Dec., 1917. Engineering, 104. pp. 561–568; Disc., 556–559, Nov. 23, and pp. 587–589, Nov. 30, 1917.)—The author describes the methods, equipment, and results of several series of tests, and discusses the theory of air-lift pumps in a manner which should permit of the evolution of rational formulæ for design. He shows also how efficiency may be improved and what data are required to check theoretical formulæ and deductions and to detect causes of low efficiency. Tests were made with clean and with badly encrusted eduction pipes, and with various foot-pieces. A simple electric contact float device is illustrated in the original for measuring lift. The latter cannot possibly be estimated correctly from the gauge-pressure of the air at the well-head. Some ejection foot-pieces put 5 to 10 lbs. extra pressure on the air, and there may be 5 lbs. loss of pressure due to friction in the air-pipe. The air pressure required to start flow is also no guide, because the lift generally increases after starting. The weight of the compressed-air column may cause the air pressure at the well-head to be less than that equivalent to the submersion head of the foot-piece.

It is very important that the volume of air used be measured accurately. This is essential to accurate determination of the average speed of the rising mixture, which is the most important item affecting the efficiency of the pump. Arrangement of test data in standard form would facilitate comparisons and avoid omissions; an authoritative body should outline a method for making and recording tests of air-lift pumps and entanglement hydraulic air compressors. The author's form of test record is very convenient.

There are at least three different methods of considering the operation of the pump as a whole. Of these the "displacement theory" is a novel method of approaching the subject, and is discussed in detail in the original. According to this theory, the same volume of liquid remains in the eduction pipe after as before the entry of an air-bubble, the arrival of which therefore causes a rise in level of the liquid in the eduction pipe. None of the energy contained in the bubble is lost until the bubble escapes into the atmosphere. A certain volume of liquid is discharged violently when the pump is started: this produces an unbalanced head, which forces liquid into that area of the eduction pipe not already filled with air. The great loss in the pump seems to be not by slip, but of this head due to entry losses. The eduction pipe should be as large as the well permits from its base to at least the level from which liquid is being raised; above this point the area of eduction pipe must bear a definite ratio to the volume of mixture flowing through it. A definite volume of air must be accumulated below the water surface in the eduction pipe (by increasing either the submergence or the air supply); otherwise the pump will not work. At the other extreme, air could be supplied so rapidly as to prevent liquid from entering the base of the eduction pipe once the original contents were discharged. Neglecting friction and slip, the volume of air required to raise a given volume of liquid is independent of the density of the latter; but the pressure and energy contained in the air injected vary with the density of the liquid. There is no rational formula for the best submersion. Average current practice

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favours 100 ft. submersion for 25 ft. lift; 200 ft. for 100 ft. lift; and 800 ft. for 800 ft. lift. The author outlines and illustrates a method of designing air-lift pumps; this should be useful, especially to those who have not an accumulation of data. A pump efficiency of 70 % should be attainable for all lifts up to 800 ft.

Pump efficiency is higher the hotter the liquid pumped, and may be 100 % when pumping water at 200° F. Many flowing oil wells are "air-lift" pumps using natural gas in place of air. The fuel consumption of an air-lift installation can be made to compare very well with that of any other type for raising liquid more than 75 ft. Centrifugal pumps are probably more economical for shallow wells. R. E. N.

25. *Testing Lubricating Oils.* **H. K. Moore** and **G. A. Richter.** (Met. and Chem. Eng. 16. pp. 692–694, June 15, 1917.)—The selection of the most suitable lubricating oil for plant operation depends upon three things: the specific conditions under which this oil is to be used, the cost of the lubricant, and the cost of power. A lubricant which is ideal for one specific purpose, may be entirely unsuitable for service with another type of bearing, or may prove uneconomical in another plant where the cost of power is different. The experiments and tests referred to in this article were conducted with a type of bearing which measured relatively the durability and also the internal friction or "power consumption" of the oil in question. The apparatus as employed in these tests duplicated also that type of bearing in which the oil is present in excess. The testing machine consisted in its essential parts of a vertical bearing-cone, rotated within a conical sleeve, the pressure being varied as required by a suspended weight on the lower part of the vertical shaft. The machine was operated by means of a ½-hp. d.c. motor through a gear-drive. The conical sleeve was made high enough to use cones of different size, and was jacketed in order to maintain any desired temperature, either high or low, at the bearing surface, and also to provide means for bringing the temperature of the bearing to any selected temperature, just previous to each successive run in a series. The power consumption or friction during the operation was measured by means of an ammeter and voltmeter. Knowing the efficiency of the motor, the results obtained by using different lubricating oils in the conical bearing became directly comparable. This comparison may also be realised by operating each time with a predetermined power input. The motor bearings and gear drive are kept lubricated with a large excess of the same lubricant all the time, and thus this factor is practically eliminated. Provision is made for several different methods of testing the oil in question. The revolving cone is furnished with a spiral feeding groove through which the oil may be brought to the bearing surface. The shaft supporting the weights is hollow, and allows the oil, after feeding through the bearing groove, to travel down to a small oil-pump which pumps the oil back into the conical bearing, thus completing the cycle. Several curves are given showing the results obtained in tests with this apparatus. J. B. C. K.

26. *Inflammability of Mixtures of Mine and Industrial Gases with Air.* **G. A. Burrell** and **A. W. Gauger.** (Bureau of Mines, Techn. Paper No. 150. [11 pp.], Washington, 1917.)—Referring to previous experiments [see Abs. 886, 484, 485, 598 (1916)], the authors tabulate the following percentages, lower and upper limits: Gasoline vapour, 1·5 to 6; ethane, 2·5 to 5; methane, 5·5 to 14·5; natural gas, 5 to 12; acetylene, 3 to 78; artificial illuminating gas,

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7 to 21; hydrogen, 10 to 66; carbon monoxide, 15 to 73; blast-furnace gas, 86 to 75. Particulars are given of experiments with blast-furnace gas, the lower limit of which varies very much, from 86 to 57 %. H. B.

27. *Apparatus for Experimenting on Belt-drives.* **M. Panetti.** (Accad. Sci. Torino, Atti, 52. 11. pp. 401–410, 1916–1917.)—Two points in the practice of belt driving are not quite ascertained. The first point concerns the influence of the speed upon the adherence of the belt upon the pulley, it being generally admitted that, within certain limits, the greater the speed the greater the adherence. The second point concerns the determination of the slip, which increases with the load far more than the theory indicates, as this latter explains the slip only as a consequence of the elasticity of the belt.

To study these two points experimentally the author has constructed an apparatus composed of a heavy truck supported by three pair of rollers rolling upon rails. Upon this cart is placed the driven pulley and the brake to load it and to measure the load. The driving pulley is fixed to the walls and is so placed that the belt is inclined to the horizon. The truck is prevented from advancing by a stout shoulder. Between this and the truck is placed an apparatus for measuring the horizontal force with which the truck tends to advance. This apparatus is composed of a hydraulic capsule connected to a manometer, the whole being filled with a liquid. A screw allows small displacements of the shoulder, and in this way the changing of the tension of the belt. From the knowledge of the angle of the belt with the horizontal, of the horizontal component of the tension of the belt, measured by the manometer, and of the force acting on the rim of the pulley of the brake, the values of the forces acting upon the driving and driven sides of the belt are obtained.

The indication of the manometer being extremely unstable in actual working, the determination of the horizontal component of the tension of the belt was made at rest, before, and after the drive, during which the manometer was just discharged by screwing two screws: at rest these were unscrewed and the push measured. The values of this push, obtained before and after the drive, were almost identical, and the mean of the two was assumed for the calculations. To avoid this operation, which might be objectionable, another apparatus, principally constituted by a lever and a weight, is being made.

The slip was obtained either by measuring at the same time the number of revolutions of the driving and driven pulleys or measuring the number of revolutions of the driven pulley when loaded and when unloaded. An apparatus for measuring the slip is being prepared and will consist essentially of an epicycloidal gear which will measure the difference between the number of revolutions of the driven pulley and of an identical pulley, but unloaded.

The results of the experiments showed that the slip increases much more rapidly with the load than the theory indicates and that speed does not appear to be favourable to adherence. The author, however, intends to make the experiments again with the new apparatus now being made. E. B.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

28. *Electric Power in the Steel Industry.* **B. Wiley.** (Power, 46. pp. 506–507, Oct. 9, 1917. Abstract of paper read before the Iron and Steel El. Eng. Assoc., Philadelphia, Oct., 1917.)—Diagrams are given showing the rapid increase in electric furnaces and electric power in the steel industry. The steel-making capacity of the mills in the U.S.A. has doubled in the last 12 years. There were 86 electric furnaces of approximately 191 tons capacity installed at Jan. 1, 1916, requiring about 40,000 kv.a. at 90 % power-factor. Attention is drawn to the waste gases usually available and their profitable use with steam turbo-generator plant. W. R. C.

29. *Preparation of Ferro-Uranium.* **H. W. Gillett** and **E. L. Mack.** (Bureau of Mines, Techn. Paper No. 177.[43 pp.], Washington, 1917.)—Uranium steel is said to have been used for guns and armour-plating by various governments since 1897, and it has recently also been recommended for tool-steel, notably by the Standard Chemical Co. According to A. F. Hoffman and C. M. Johnson [J. Ind. and Eng. Chem. 8. p. 949, Oct., 1916] such steel did good work only for a few grindings, however, and soon required re-hardening. Having reviewed the literature on the metallurgy of uranium, and given a useful bibliography list, the authors describe their own experiments on the preparation of ferro-uranium from the pure oxide UO_2—pitch-blende is essentially U_3O_8—pure iron, low-ash coke, and some flux (alumina, or fluorspar) with or without lime in electric furnaces with 2 suspended vertical electrodes on single-phase circuits; three-phase would have been preferable. Nearly 100 runs in 8 different furnaces are mentioned. As UO_2 is not reduced below 1500°, and has a density of 11 (density of the metal 18·7) whilst the density of iron is less than 8, a flux floating on the fused iron has to be provided from which the iron can take up the uranium. The first furnace used was a tilting furnace, having a graphite hearth of 5 by 8 in., 3½ in. deep to the spout, into which a tapping electrode was inserted. Charges of about 4 lbs. of iron, 6 of UO_2, 1·5 of coke, and flux gave, with 30 to 60 kw. at 60 to 90 volts (power-factor 0·90 to 0·95) an alloy of about 44·5 % of U, 10 % of U being lost in the slag and by volatilisation. The alloy contained 4 or 5 % of carbon, partly taken up from the hearth; when silicon or silica were added to keep the carbon low, the silicon volatilised, but also entered the alloy and made it brittle. A layer of UO_2 was therefore sintered into the hearth; this cracked off, however. Hearths of magnesite, zirkite, etc., did not stand more than a very few heats. A water-cooled hearth was adopted, therefore, first in a stationary furnace; magnesite linings could then be maintained, and the larger, third furnace, again of tilting type, worked satisfactorily. It was lined with carborundum-brick, which, however, was corroded by the slag. The slag must not be too viscous, nor too fluid; in both cases it would spatter, in the latter case it would boil; about 60 lbs. of UO_2 (half of which serves as hearth lining) requires 10 lbs. of CaF_2. Alumina partly enters into the alloy, which may be tolerated, since ferro-titanium is rather improved as steel refiner by the presence of some Al (from the thermit reduction); this question is being investigated with regard to uranium. In stationary furnaces the reaction is limited to the neighbourhood of the electrodes. Alloy crystals with 30 % U and more and about 5 % carbon resemble large stibnite crystals,

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and can easily be crushed; low-uranium alloys are crystalline, white and dense. The pyrophoric character becomes more pronounced with increasing U percentage, but depends also on the C and Si which affect the brittleness. The determination of the melting-points of the alloys by the micropyrometer proved difficult; the alloys softened gradually, but seemed all to be completely melted at 1600° C. As iron does not readily take up uranium, and is cooled by this dissolution, and as U is lost during the operation by oxidation, it is possible that some so-called uranium alloys hardly contained any U; losses of ½ of the metal have been observed. The ferro-uranium should be added to the steel just before pouring or during pouring. One company pours the steel from an electric furnace into a bottom-pour ladle, lets it flow from this ladle into a second ladle, and adds the alloy to the stream in pieces of hickory-nut size; the steel is then held in the second ladle for 3 or 4 minutes before pouring. Refining a high-carbon alloy first prepared (Bleecker) did not answer.

The conclusions are that pure UO_3, pure iron, a low-ash coke or charcoal, CaF_2 as flux, a tilting electric furnace with water-cooled magnesite hearth and sides should commercially yield, on three-phase circuits, ferro-uranium with 40 to 70 % U, less than 2 % C, 0·76 Si, 0·5 V, and traces of other elements, at a consumption of less than 3 kw. per lb. of alloy. If further experiments should prove that high-uranium steel is not valuable, but that low-uranium steel is, and that 4 or 5 % carbon would be harmless, then a furnace with an uncooled carbon hearth might be used. To serve merely as deoxidiser or scavenger of oxygen and nitrogen, an alloy containing Al might not be harmful, and alumina might be used as slag-former. H. B.

30. *Production of Titanium Oxide.* (U.S Pat. 1,285,688. Met. and Chem. Eng. 17. pp. 439–440, Oct. 1, 1917. Abstract.)—L. E. Barton dissolves the titaniferous material, ores or, by preference, the titanic acid produced according to U.S. Pat. 1,171,542 (A. F. Rossi and Barton), in acid, generally sulphuric acid, and electrolyses the solution at 90° to 95° C. with lead electrodes at 5 to 10 volts and 30 amps. per sq. ft. in diaphragm cells, the anolyte being sulphuric acid. The precipitated titanium hydrate is calcined at 750° and converted into titanium oxide. H. B.

31. *Aluminium and Silicon from Clay.* (U.S. Pat. 1,288,604. Met. and Chem. Eng. 17. p. 489, Oct. 1, 1917. Abstract.)—V. M. Weaver treats the clay with chlorine gas at temperatures between 900° and 1200° C.; the aluminium chloride and silicon tetrachloride are condensed. The former is kept at 200° and a pressure of about 2·5 atmos., and then fed into an electrolyser containing fused NaCl; metallic Al and chlorine are produced. The silicon chloride is fed into a vat containing molten Al; Si is reduced and aluminium chloride formed, which latter is treated in the electrolyser. H. B.

32. *By-products in Electrolytic Copper Refining.* **L. Addicks.** (Met. and Chem. Eng. 17. pp. 169–176, Aug. 15, 1917.) [See Abstract 578 (1917.)]—The author discusses the working up of the anode slimes, furnace slags, and flue-dust obtained as impurities in the electrolytic copper-refining process, and the marketing of the products obtained. The possible by-products may be divided roughly into three main classes: (1) those which are readily marketable, in any quantity which such sources are ever likely to supply, (2) those which have a limited and therefore sensitive and widely fluctuating market, and (3) those which at the present time have practically no market at all. These groups consist of the following: (1) Au, Ag, Pt, Pb, Ni, and Si; (2) Bi As, Co, Se; and (3) Te.

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Palladium is the only uncommon member of class (1). The production of this element is as yet quite small, and this amount is readily absorbed by the jewellery and scientific-instrument trade. Practically it has the useful qualities of platinum, but is of about half the density. *Bismuth* goes chiefly into the drug trade. Any large production of it floods the market and depresses the price. There is a large market for *Arsenic*, which is used chiefly for its poisonous properties in insecticides, etc., but in recent years the great output of arsenious oxide recovered from smelter flue-dusts has glutted this. *Cobalt* is an element that has not yet found itself. The Canadian Government has conducted a wide investigation as to its possible uses, but aside from the use of cobalt oxide in the manufacture of smalt and for whitening yellow pottery, and the use of the metal to give certain minor properties to cobalt-plated ware and cobalt alloys, no marked characteristic giving it a superior value to Ni has been discovered, and so far it has not been found possible to produce it at the price of Ni. *Selenium* was a rare element a few years ago; to-day a single copper refinery could easily produce ten tons a month, provided it could be marketed. Its peculiar photoelectric property has not created any tonnage demand, and its only major use is for colouring ruby glass. This creates a steady but very moderate market. *Tellurium* could also be produced by the ton, but there appears to be no reasonably extensive market for it. It would seem, therefore, that the various plants producing Se and Te could advantageously join in trying to develop wider markets for these elements by scientific research.

The remainder of the article deals with the metallurgical methods by which the various by-products are separated. According to the author, future developments are likely to be along the lines of a flotation process which will remove the Ag and Au at once from the slimes instead of holding them until all the other impurities have been removed, that is, to the end of a long series of metallurgical and chemical operations. The major part of the value in the slimes is therefore held back from the market, and this adds greatly to the capital locked up in the slimes department.

J. B. C. K.

33. *The Manufacture of Calcium Carbide in Australia.* (Mining and Eng. Rev. 9. pp. 290–291, Aug., 1917.)—These Works are the first of their kind in Australia and have been designed by C. H. Halldin; they are erected upon the property of the Hydro-Electric Power and Metallurgical Co., a subsidiary of the Complex Ores, Ltd., at North-West Bay, 15 miles south of Hobart, Tasmania. The Company owns leases of first-class limestone at Ida Bay, near Southport, and works to produce coke of the quality suitable for the manufacture of the best carbide are being erected. The limestone is landed at the wharf, hauled up a tramway, and discharged at the point required where it is burnt in a lime-kiln of the latest design with continuous discharge. The lime from this kiln is crushed and elevated into bins in the crushing-house; it is then automatically weighed and mixed with the requisite amount of crushed coke. The mixed material is now conveyed into the furnace-house, containing an electric furnace of 8500 h.p. Current is supplied at 6600 volts, and transformed down to about 75–80 volts. At this pressure 88,000 amps. pass through the furnace, which is of the 3-phase type, having three top electrodes (one to each phase) suspended in the furnace and regulated by means of electric gearing. The furnace body consists of a rectangular shell of sheet-iron lined with refractory material; in the bottom of this is a neutral electrode which assists in starting the furnace.

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The raw material is fed into the furnace by a series of shutes—the melting-zone is at the lower ends of the top electrodes, the temperature being about 3200° C. When the furnace is in normal operation the molten bath of carbide extends over the bottom, and as carbide in the molten state is a good conductor, it takes the place of the neutral carbon electrode. The furnace has 6 tap-holes, 3 on each side, opposite the electrodes. The carbide is tapped into trucks or ingot moulds. The trucks pass into the cooling-house where the calcium carbide solidifies, and after cooling the ingots are broken up and passed through a jaw-crusher—after which the carbide is elevated into the packing-house in which it is further crushed, screened, automatically sorted and packed into drums according to size. Both the raw material and the carbide crushing-houses have all the dust drawn off from the various machines by means of exhaust-fans, and collected by special dust-collecting apparatus. The initial capacity of the plant will be 5000 tons of calcium carbide per annum, but provision has been made in the buildings for double this output. J. B. C. K.

34. *Preventing Electrolysis of Iron in Concrete.* **W. A. Del Mar** and **D. C. Woodbury.** (El. World, 70. pp. 916–917, Nov. 10, 1917.)—Description of some experiments, extending over 120 days. Iron rods were embedded in concrete, either one or three in each block, the blocks were placed in water from the mains, and the rods so coupled upon a 120-volt circuit that 2 rods were anodes, 2 kathodes, and 2 unconnected. Only the anodes corroded, and their resistance (determined as ratio of volt to amps.) increased. When the current was interrupted the resistance fell, to rise again on re-establishing the circuit. This change is ascribed to electric osmosis, demonstrated by a simple experiment. Some iron rust is placed in a U-tube, and water poured over it; in a tube 7 mm. internal diam. a current of 0·05 amp. moved 1 cm.³ of water in four hours through 10 cm. of rust. Such a dehydration and increase in resistance also take place with an iron rod coated with paint; the dry film of rust or paint (if insulating) prevents further electrolytic corrosion. H. B.

35. *Galvanometer for Alternating Currents.* **Pestarini.** (Electrician, 80. pp. 154–156, Nov. 2, 1917.)—The galvanometer consists of a fixed and a movable coil, the former being shown in the diagrams as wound on a magnetic core. One of the coils is fed from an auxiliary source through a phase-transformer and the other carries the current to be measured. The moving coil may be controlled by a torsion suspension and the phase transformer is rotated until the galvanometer gives a max. deflection. This deflection will then be proportional to the current to be measured. In another form of the instrument the moving coil is suspended without control and the instrument is used in a similar manner. The instrument may be used as a phasemeter by noting the relative position of the primary and secondary windings of the phase transformer that gives the max. deflection. The frequency of a current may be measured by passing it through one of the coils and supplying the other coil at a variable frequency and determining the frequency for which the galvanometer gives a steady deflection. If a current contains a series of harmonics, these may be determined by the method just referred to by noting the series of frequencies for which maximum deflections are obtained. These max. deflections will be proportional to the amplitudes of the various harmonics. A. J. M.

36. *Current-limiting Reactor with D.C. Excitation.* **F. P. Coffin.** (Gen. El. Rev. 20. pp. 821–824, Oct., 1917.)—Describes a device for obtaining

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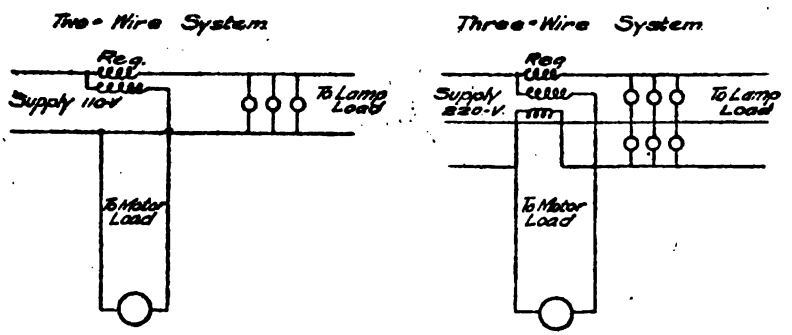
power for experimental purposes from an a.c. supply system, so arranged that the current taken from the system is limited in value in the event of a short-circuit in the experimental apparatus. Power at 40 ∿ and 10,000 volts is transformed to 570 volts by a step-down transformer. The secondary circuit of this transformer contains the primary of another transformer, which steps up to 2800 volts on the secondary, and two auto-transformers, these latter being used to regulate the supply current. Alternating current passes through the secondaries of the auto-transformers, which are connected in parallel. The primaries of the auto-transformers are in mutual opposition, as regards alternating current. Direct current is passed through the primaries, thus polarising the core and allowing the alternating magnetising current, which flows through the secondaries, to be increased beyond its normal value when the core is unpolarised. Curves are given showing the relation between the d.c. excitation and the alternating current in the secondary of the step-up transformer on short-circuit. The power drawn from the supply system varied from small amounts up to 800 kw. single-phase. N. W. M.

37. *Voltage Stabiliser for combined Lighting and Motor Circuits.* (El. Rev. and West. Electn. 71. pp. 865–866, Nov. 17, 1917.)—Describes and illustrates the General Electric Co.'s (U.S.A.), a.c. voltage stabiliser which eliminates



pressure fluctuations in combined lighting and motor circuits. The device is essentially a highly reactive transformer with a primary through which the motor current flows and a secondary which is connected in series with the lamp load and boosts by an amount proportional to the voltage drop caused during starting or load change of the motor. The magnetic circuit of the stabiliser comprises a laminated core with an adjustable air-gap. The motor and lamp coils are interwound on the middle core leg. A rush of current through the motor coil induces an e.m.f. in the lamp coil, substantially in phase with the lamp voltage. At normal full-load motor current the flux density in the stabiliser core is low and the voltage drop is correspondingly low. Owing to the air-gap, the stabiliser is highly reactive and most of the pressure drop over the motor coil is in quadrature with the line voltage, except for core and copper losses which must be kept low.

The stabiliser may be applied to any power apparatus operating with lighting loads; it may be used for general industrial purposes, for hotels and apartment houses, and for small isolated stations. The method of application varies with the nature of the load, especially when the starting power-factor varies over a wide range. The Fig. shows connections for 2-wire and 3-wire single-phase systems. A 2-phase system must generally

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be treated as two 1-phase systems and have two stabilisers, unless only one phase is used for lighting. Three-phase systems may be regulated considering each phase singly; one stabiliser suffices if only one phase is used for lighting; three stabilisers are needed if all three phases are used for lighting. High efficiency results from the low flux density in the cores and the liberal copper section. R. E. N.

38. *Rating of Fuses.* **A. B. Eason.** (Post Office El. Eng., J. 10. pp. 97–110, July, 1917. Electrician, 80. pp. 77–80, Oct. 19, 1917. Abstract.)—The article deals with the question of fusing currents in open and enclosed fuses for carrying 8 to 100 amps. at 250 and 500 volts and carrying 60 to 1000 amps. at 22 and 40 volts; such fuses are used in telephone exchange work. The relative merits of open and enclosed fuses are discussed. The main features to be considered in comparing open and enclosed fuses are danger from molten metal, provision of cooling of the vaporised metal, reliability of the calibration, ease and cheapness of replacement, first cost, and liability to corrosion. The chief investigations that have been published relating to the testing and standardisation of fuses are summarised. A mathematical treatment of the problem results in a formula connecting the instantaneous current and the radius of the wire fused. If i is the instantaneous value in amps., s the specific resistance of the wire in cm. units, θ the temperature of the wire in deg. C. and R the radius of the wire in cm., then $0{\cdot}239i^2s(1+a\theta)=f_1R^4+f_4R^{3\cdot5}+f_3R^3$, where a is the temperature coefficient of electrical resistance of the wire per deg. C. and f_1, f_4, and f_3 are quantities depending on the fusing temperature of the wire and its heat conductivity. A table is given from which the values of these quantities may be obtained for wires of different materials. It is common to take the simple relation $i=kR^n$ and the above equation reduces to this form if two of the factors f are negligible. A. J. M.

39. *Resistivity of Aluminium.* **G. Grassi.** (Elettrotecnica, 4. pp. 543–544, Oct. 25, 1917.)—The author has measured the resistances of Al wires at different temperatures between 0° and about 100° C. Three specimens of wires of different origins were measured; they contained more than 98 % of Al, the chief impurities being Fe and Si. The measurements were chiefly made by the Hockin and Mathiessen method. Preliminary experiments showed that the increase in resistance in the temperature interval aforesaid was proportional to the temperature, so that the resistance could be exactly represented by the formula $R_T=R_0(1+a_0t^\circ)$, where a_0 represents the temperature coefficient at 0°. If a_t is the temperature coefficient at t°, then $R_0=R_T(1-a_tt^\circ)$ from which $a_t=a_0/(1+a_0t^\circ)$ and $R_0a_0=R_a=$ Constant.

The resistivity per metre/mm.² at 0° was found to lie between 0·02620 and 0·02763 ohm and a_0 between 0·004097 and 0·004353; if annealed, the resistivity was lower and a_0 higher, so that the product $R\times a$ was practically constant at all temperatures, whatever the origin of the wire and independently of annealing, and equal to 0·00011354. The samples of wire richest in Al had the lowest resistivity. E. B.

40. *Abac for the Temperature of Windings.* **A. Castex.** (Rev. Gen. d'Él. 2. pp. 763–764, Nov. 17, 1917.)—The accompanying abac is for determining the temperature of a winding by reference to its resistance. Valensi's cartesian chart for the same purpose is rather difficult to read owing to the risk of confusion in the many lines of which it is composed. Also, interpolation is not very safe and the max. resistance provided for is 10 ohms. The author's alignment nomograph is based on the assumption that the temperature

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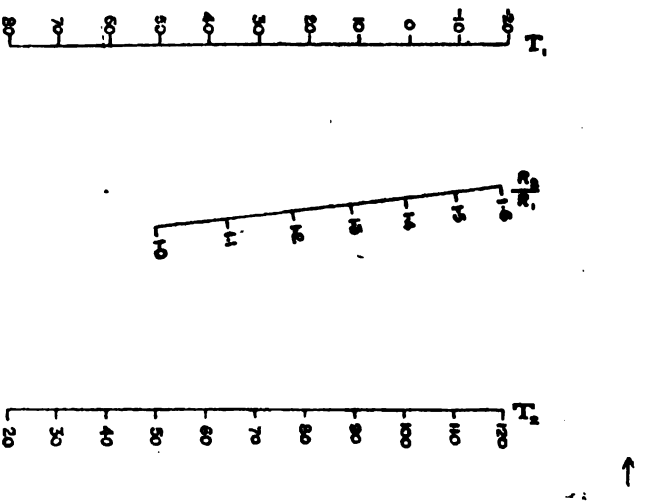
coefficient of resistance of copper remains constant within the temperature limits of industrial machinery. Then, if $(1 + \alpha T_1) = U$, $(1 + \alpha T_2) = V$, and $R_2/R_1 = W$, we have $V = WU$. The nomograph for this function has 8 rectilinear scales of which two are parallel. The author states the principles to be borne in mind when selecting scales and laying out the chart.

It is suggested that a convenient size for the diagram is 7·5 cm. between parallel scales; each of the scale divisions in the present reproduction is divided into tenths in the original; the T_1 scale extends from $-20°$ to $+ 80°$ C.,



the T_2 scale from $+ 20$ to $+ 120°$ C., and the R_2/R_1 scale from 1 to 1·6. These ranges cover all practical requirements. To determine T_2 from the measured values of R_1, R_2 and the atmospheric temperature T_1, it is only necessary to calculate R_2/R_1 and draw a line (or hold a straight-edge) through the corresponding values of T_1, R_2/R_1; T_2 is then indicated at the intersection with the right-hand scale. The chart may also be used to find R_2 corresponding to T_2.

R. E. N.

41. *Changes in the National Electrical Code.* (El. World, 70. pp. 826-827, Oct. 27, 1917.)—Few changes were made in the National Electrical Code by the electrical committee of the Fire Protection Association at the annual meeting, Oct., 1917. The next meeting is to be held in 1920. Several new committees have been appointed to deal with :—(1) The use of lead-covered cables for extensions in fireproof buildings. (2) Additions to the code to meet the needs of apparatus for lower than 50 volts. (3) Re-editing sections of the code to eliminate class D. The next edition of the code is to be ready Jan. 1, 1918. A "new System and Devices Committee" has been appointed to investigate all new systems and devices in co-operation with the Underwriters' Laboratories.

The new paragraph on isolating lightning arresters formerly read "on circuits over 7500 volts." This has now been changed to "all arresters." Several changes have been made in respect of induction motors. Rule (8) *c* now commences: Except for auto-starters, the switch specified in the preceding paragraph may be omitted where the motor starter disconnects all the

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circuit wires. If an auto starter be used a switch must be provided on the supply side of the starter. If when the starter is in the running position, it opens automatically under overload, it may serve also as circuit-breaker.

Recommendations from the committees on transformers and electric signs were accepted; but the circuit-breaker report was withdrawn. By the rule on outlet, junction and flush-switch boxes it is now prescribed that junction or pull boxes having not more than 150 cub. in. contents, outlet boxes, and flush-switch boxes must all be of pressed steel not less than 0·078 in. thick, or of cast metal with wall thickness not less than $\frac{1}{8}$ in. An amended rule on grounding reads:—"Metal conduit containing service wires must be grounded . . . except under the following conditions: (1) Conduit containing no conductors of circuits except 150 volts to ground may be ungrounded if insulated from ground and from metal conductors, metal raceways, armoured cable, and all other work on or in the building. (2) Conduit containing conductors exceeding 150 volts to ground may be ungrounded if insulated as above and also isolated or guarded."

The rule on fixtures has been changed in respect of the conditions under which insulating joints and canopy insulators may be omitted. The committee recommend that "grounding be extended to all utilisation devices including sockets, fixtures, receptacles and even portable devices." More severe specifications and tests are asked for ground clamps. It is recommended that all ground clamps be of copper not less than $\frac{1}{16}$ in. thick; no iron or steel should be used except possibly for the clamping bolt; the connecting lug should be an integral part of the clamp.

Meters should be placed together, not scattered through a building. The paragraph in the rules relating to the function of service switches has been rearranged. Refillable fuses may, for the present, be used if they comply with tests and specifications for cartridge fuses and are approved by the inspection departments concerned. The table of spacings for switches other than on switchboards has been rearranged and it is specified that switches above 1000 amps. are to be used only for isolating purposes. Amongst miscellaneous recommendations there is one providing for reverse-phase relays or equivalent devices on certain a.c. motors dependent on phase for their direction of rotation. Motors (except for railways) "must be provided with name-plate giving maker, volts, amps., and full-load speeds at interval duration, which operate safely, starting cold." An amendment on switches relates to the method of mounting them at outlets, etc. A new rule is added concerning the electrical control of sounding apparatus and keyboards in electric organs. R. E. N.

42. *Calculation of Choking Coils.* **M. Korndörfer.** (Elekt. Zeits. 88. pp. 521–523, Nov. 1, 1917.)—Two empirical formulæ are given for the self-inductance of cylindrical coils of rectangular cross-section, namely: $L = 10{\cdot}5\, z^2\, D \sqrt[4]{(D/U)^3}$ cm. ... (1) and $L = 10{\cdot}5\, z^2\, D \sqrt{(D/U)}$ cm. ... (2), where z = number of turns in series, D = mean diam. of coil, and U = circumference of section of coil. Formula (1) is to be used if D/U lies between 0 and 1, while (2) is suitable for cases where D/U is between 1 and 8. When D/U = 8 the formula gives results which are about 8 % too high. For iron-cored choking coils with air-gaps a formula is derived which gives the volume of the air-gaps in terms of the kv.a. (X) to be absorbed. When the length of the air-gap is only a few millimetres the fringing of the magnetic lines can be allowed for by adding to the area of the iron pole-face a circumferential strip with a width equal to the length of the gap. When a considerable volume is required in

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the air-gap it is usual to employ several short air-gaps in series. The total volume is given by $V = 8X/[(H/10,000)^2 . 2f/100]$ cm.^{3}, where H = magnetic field strength in the air-gap and f = frequency. The density in the iron is assumed at the outset and the kv.a. required for its magnetisation are deducted from the total to be absorbed, before the above formula is applied.

F. T. C.

43. *Design of D.C. Solenoids and Plunger Magnets.* **G. L. Hedges.** (El. World, 70. pp. 754-757, Oct. 20, 1917.)—The usual method of designing a plunger magnet is to assume in turn a number of different plunger diameters, and calculate the amp.-turns needed for the required pull, and the winding for the required amp.-turns. The author presents formulæ and charts for determining the cheapest, lightest, or smallest magnet with much less labour. Cylindrical magnets for use with direct current are alone considered. Approximate pull curves are given for a solenoid equal to or greater (in length) than 12 × plunger diam.; also for a shorter plunger. The max. useful work available from a solenoid = effective pull × stroke; other conditions being equal, the longer of two solenoids is the more economical. The condition for max. useful work with long or short solenoid is $W_s = F_s p D_i$; where $p = q - 6 = (L/D_i) - 6$ for long solenoids and $p = q^2/24 = L^2/24D_i^2$ for short solenoids. Here W_s = solenoid useful work, in inch-lbs., F_s = solenoid pull in lbs., p = stroke/plunger diam., D_i = inside diam. of winding = plunger diam. (both in inches), q = length of coil/plunger diam., L = length of coil in inches. The pull of a plunger electromagnet is made up of the solenoid pull (between winding and plunger), and the core pull (between core and plunger). The core pull is predominant with the comparatively short strokes generally employed. Formulæ are given for core pull, winding thickness, and total volume. For a given type of magnet, the volume, weight, and cost of the magnetic circuit are proportional to the internal volume of the winding. The author shows that if the total pull, stroke, or useful work be given, the inside diam. of the winding or the plunger diam. may be calculated. Thence the amp.-turns or winding thickness may be calculated for the smallest, lightest, or cheapest magnet.

A collection of working formulæ and charts is presented for the complete design of solenoids and plunger magnets, for continuous and intermittent service, based on the following data: Heat radiation, 0·4 watt per sq. in. in continuous service; temperature-rise 0·67 deg. C. per sec. in intermittent service; length of coil = 12 × plunger diam. in solenoid work, and stroke = 6 × plunger diam. In plunger magnet design, stroke = 0·8 × plunger diam. = 0·8 × length of coil.

An electromagnet may be required to exert a given pull through a given stroke, or to perform a given amount of work. The author makes the following recommendations: Solenoids for long uniform pull; plunger electromagnets for short, strong pull. For the performance of a given amount of work, use solenoids where the pull should be uniform throughout the stroke, and plunger magnets where it is advantageous to increase the pull towards the end of the stroke. Using the author's formulæ and charts, the stages in design are to assume a wire size and find the value of D_i corresponding to this size of wire and for the specified pull or work; find the ampere-turns per in. of length; design the winding; if necessary repeat, using the size of wire found by the first trial. There may be a considerable error in the initial assumption of wire size without materially affecting the accuracy of the results. There is little difference in plunger diam. for a given pull or

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work with sizes of wire ranging from 1/0 to No. 20. Curves for amp.-turns per in. and winding thickness show large values for small plunger diam. and small values for large plunger diam., but the curve for magnet volume, weight, or cost shows a pronounced minimum, and it is the plunger diam. for this minimum which is given by the present formulæ and charts.

With proportions of magnets approximately as given, and sufficient amp.-turns to saturate the plunger, the formulæ give results near enough for practical use, especially since a factor of safety should be allowed to cover the weight of plunger and the plunger and mechanism friction. The required useful pull or work should be increased by about 50 % in designing solenoids and by 25 % for plunger electromagnets. The lower margin is sufficient in the latter case because the author's formulæ neglect the solenoid pull in the case of plunger magnets. R. E. N.

44. *Energy Diagrams of an A.C. Electromagnet.* **A. Thomälen.** (Elekt. Zeits. 88. pp. 473–474, Oct. 27, 1917.)—The mechanical work performed during the stroke of a d.c. electromagnet has been determined by Emde [Abs. 1064 (1908)] by means of a diagram connecting the values of the current and the flux produced for the initial and final positions of the armature. The work done is given by the area of a surface contained between these two curves. The method is now applied to the case of an a.c. electromagnet. Dividing the stroke up into periods it is shown that in the first quarter of a period the energy supplied is used to perform the motion of the armature and store up magnetic energy. In the second quarter of a period the decrease in magnetic energy is equivalent to the work taken to give a stroke of the armature and supply the energy returned to the line. It follows that in a half-period starting from the moment that the flux passes through zero the electrical energy supplied is equal to the work done by the armature. It is shown that if H is the max. field strength in the air-gap of area F, and if the stroke is σ in half a period, the work done in half a period is $H^2F\sigma/(16\pi)$, and that the difference of the magnetic energy stored at the beginning and end of the stroke is twice this value. A. J. M.

45. *Obtaining Approximate Values of Harmonics.* **W. V. Lyon.** (El. World, 70. pp. 949–951, Nov. 17, 1917.)—The author gives a straightforward substitution method of obtaining the form of the no-load current wave for a transformer, when the equation of the applied e.m.f. wave and the hysteresis loop are given. Harmonics up to the seventh can be determined with good accuracy by taking eight points in one half-cycle. F. T. C.

46. *Synchronising with Lamps.* **F. A. Robbins.** (El. World, 70. p. 818, Oct. 27, 1917.)—The author advances arguments (based on phase relations) which indicate that synchronising dark is more accurate than synchronising light when lamps are employed. The usual argument in favour of light-synchronising is that a small reduction from normal voltage can be detected easily whereas a considerable voltage is required before a dark lamp will glow.

In dark synchronising the voltage OC across the lamps is the vector sum of the alternator e.m.f.'s OA, OB (Fig. 1). When synchronising light, the voltage across the lamps is the vector difference AB (Fig. 2). Even for small angles θ of phase-difference the line OC has appreciable length, whereas the angle θ must be quite considerable before AB differs appreciably from OA + OB. In order to make the filament just visibly luminous (in a well-lighted room) a carbon lamp needs 25 %, and a tungsten lamp 8 % of normal voltage.

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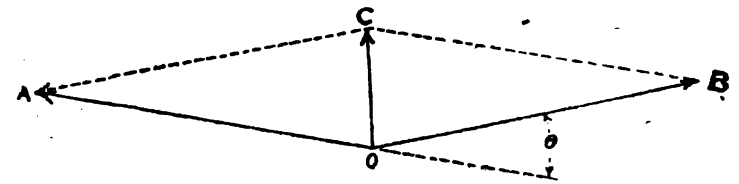
The voltage decrease needed for the eye to detect the decreased brilliancy with certainty is 8 % with carbon, and 6 % with tungsten lamps. From these data and the Figs. herewith, it is easy to show that the smallest phase-difference θ which can be detected is (*a*) when synchronising dark, 29° with carbon and 9½° with tungsten lamps; (*b*) when synchronising light, 28° with carbon and 42° with tungsten lamps. Carbon lamps are best for "light" synchronising and tungsten for the dark method. A number of tests show that dark synchronising is rather more accurate than light synchronising when using carbon lamps; and much more so when using tungsten lamps.



The possibility of a lamp burning out whilst synchronising by the dark method, thus leading to a false indication, may be guarded against by paralleling two sets of lamps, set so close together that both sets may be watched at once. R. E. N.

47. *The Rhodes-Firth Lighting and Engine-starting Set.* (El. Rev. 81. pp. 453–454, Nov. 9, 1917.)—In the car-lighting set, the dynamo is driven through friction gearing comprising a disc on the dynamo shaft and a friction wheel which is mounted on a driving shaft arranged at right angles to the dynamo shaft. This friction wheel is moved along the driving shaft by a centrifugal governor, so that the place where it bears against the disc travels away from the centre of the disc as the speed of the driving shaft increases, and thus the speed of the dynamo is kept constant. This movement of the friction wheel also controls, through a system of levers, a switch which only closes the dynamo circuit when the voltage is sufficiently high to enable it to be connected to the storage battery. In a modified construction, for use in starting a car, the end of the dynamo shaft bears a small bevel pinion that gears with a bevel wheel on the friction wheel when the latter is in its initial position, *i.e.* nearest the centre of the friction-disc. Means (not described) are also provided for locking the friction wheel in this position until the speed has risen to a predetermined value. A double arrangement is also described for train-lighting, in which there are two friction-discs arranged opposite each other on the dynamo shaft with the friction-wheel between them. In this case, the bearing carrying the driving shaft and friction-wheel is rocked as the direction of rotation of the driving shaft changes, so as to bring the friction wheel into contact with the friction-disc that will rotate it in the desired direction. This rocking motion is produced by the drag of a bevel driving wheel on a pinion on this driving shaft, the drag being obviously changed in direction when the direction of rotation of the bevel driving wheel is changed.

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48. *Theory of the High-tension Magneto.* **A. P. Young.** (Electrician, 79. pp. 922–924, Sept. 14; 968–966, Sept. 21, and 80. pp. 7–9, Oct. 5, 1917. Abstract of paper read before the Aeronautical Soc.)—After a brief *résumé* of the history of the high-tension magneto, the theory is carefully discussed on practical lines. The paper also gives the results of detailed tests of a B.T.H., 8-cylinder, type A.S.S. sleeve inductor magneto designed to give 4 sparks per revolution. In the contact-breaker, a pivoted steel bell-crank lever arm carries at one end a fibre block, which is actuated by a rotating 8-part hardened steel cam rigidly fixed to the distributor brush spindle, while at its other end the movable Pt contact screw is secured. A very strong steel spring fixed at one end to the contact lever arm and at the other end to the base plate serves to force the movable contact tightly against the adjustable fixed contact, when the cam is not in engagement with the fibre heel. The contacts are opened 8 times during each revolution of the cam shaft, which rotates at half the speed of the sleeve inductor, thus giving 4 breaks per revolution of the latter. The max. value reached by the flux wave is approximately 82,000 lines, so that assuming a leakage coefficient of 1·4, the magnet flux works out at 45,000 lines. The flux-density in the magnets is 5900 lines per cm.^{2}, and in the armature core 8500 lines per cm.^{2}. The max secondary voltage at very high speeds is in the neighbourhood of 8000. Curves are given showing the waves of flux and voltage at 1000 r.p.m.; the self-induction for different positions of the sleeve inductor; the primary current curves for different speeds; the connection between max. primary current and the corresponding phase displacement; the variation of available energy and primary current with speed; the variation of sparking voltage and energy with speed; the variation of short-circuit current and open-circuit voltage with speed; and the variation of efficiency with speed. The paper also gives notes on the installation and care of a magneto; it includes also a discussion of the various methods of engine-starting, and of the different battery ignition systems. C. A.

49. *Comparative Tests of Coal, Kerosene, and Electricity for Cooking.* **B. L Steele.** (Canad. El. News, 26. pp. 22–24, Oct. 15, 1917. Electrician, 80. p. 846, Dec. 7, 1917. Abstract.)—These tests were made at the State College of Washington, and the following are some of the results obtained. The average efficiencies of the various stoves were :—

	Per cent.
Coal range (entire space utilised)	18
„ „ (usual home cooking)	2
Flame contact burners (kerosene, etc.)	28
Electric heaters (surface)	45 to 65
„ „ (enclosed)	70
„ „ (immersion)	90

With the average value of the kilowatt-hour at 8·85 cents and coal at $10 per ton, the cost per meal for electricity was 8·85 cents; for coal without water heating 8·65 cents, and with water-heating 5·85 cents. The cost of cooking breakfast on the electric range was, however, 2·8 cents per meal, against 3·3 cents for the coal range without water-heating. C. A.

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GENERATORS, MOTORS, AND TRANSFORMERS.

50. *Magnetic Pull on Armatures of Electrical Machines.* **E. Rosenberg.** (Elektrot. u. Maschinenbau, 35. pp. 525–531, Nov. 4, and pp. 539–546, Nov. 11, 1917.)—If the armature of an electrical machine is mounted excentrically, a one-sided magnetic pull is exerted. This pull depends on the state of saturation of the iron and, if the machine has salient poles, the pull reaches a maximum at a comparatively low saturation and decreases again at higher excitations. If the excentricity is x and the "virtual" air-gap is a (*i.e.* the gap that would absorb the same m.m.f. as the actual gap together with the iron path belonging to one pole), then the max. value of the one-sided pull is given by $F = c\pi DL(B/5000)^2(x/a_1)$, where πDL is the cylindrical surface of the armature and c has a value nearly equal to 2/3 (except for 2-pole machines with salient poles, for which c is about 0·4) and B is the flux density at the point on the saturation curve for which the inclination of the curve is about 5/6 of that of the straight part of the curve. In the case of 2-pole machines the one-sided pull is different if the excentricity is in the direction of the field or perpendicular thereto. The latter displacement gives the greatest pull. When the machine is suddenly excited an oscillatory motion of the shaft is set up and, if the greatest amplitude is to be less than the value that would cause the armature to touch the field system, the steady bending of the shaft and of the frame of the machine should not exceed 1/6 mm. with an original excentricity of the shaft of 1 mm. The "critical" speed of the shaft, at which the oscillations are of a resonant nature, is lowered by the one-sided magnetic pull by about $q/2$ %, if an excentricity of 1 mm. causes the shaft to bend by q hundredths of a mm. For multipolar machines with parallel windings and suitable equalising connections there is no such decrease in the critical speed. A. J. M.

51. *Compounding of Synchronous Alternators.* **M. Liwschitz.** (Elektrot. u. Maschinenbau, 35. pp. 465–468, Sept. 30; 477–484, Oct. 7, and pp. 491–496, Oct. 14, 1917.)—The use of automatic voltage regulators, such as the Tirrill regulator, has displaced other methods of voltage regulation of synchronous alternators on account of the quickness of action attainable. It is now shown, both by calculations and by experiments, that equal speed of action may be attained by the use of synchronous exciters. The type that is discussed is the arrangement due to Danielson, in which the alternator field is excited from an armature that is excited by alternating current derived from the main supply through current transformers. There are four circuits involved that are electromagnetically interlinked. These consist of (i) the alternator armature, primary windings of the current transformers and external load, (ii) the secondary windings of the current transformers and paths through the exciter armature through the slip-rings, (iii) the alternator field and path through the exciter armature through the brushes on its commutator, and (iv) the exciter field and d.c. source of supply.

The differential equations of these four circuits are given and the solution shows that with suitable values of the self- and mutual-induction coefficients of the circuits the speed of action of the compounding is comparable to the speed with the Tirrill regulator. Tests bear this out and oscillograms are reproduced to show that the rate of variation of the field current of the alternator may be correctly calculated by the formulæ obtained. A. J. M.

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52. *Comparison of Synchronising Methods.* **E. Styff.** (Elekt. Zeits. 38. pp. 461–465, Sept. 20, 1917.)—The synchronising of alternators may be effected by phase lamps or by voltmeters. In either case various connections are possible, and the synchronising may be carried out with the lamps bright or dark. The sensitiveness of the methods may be given by a factor k defined by $k = [dA/d\phi]_{\phi=0}$, where A is the indication of the synchroniser and ϕ the phase-difference between the machines. We may write the above relation in the form $k = [dA/dV]_{\phi=0} \cdot [dV/d\phi]_{\phi=0}$, where V is the voltage applied to the synchroniser. The first of these two factors is a function of the design of the instrument employed; and the second, of the method of connecting the synchronising apparatus. A number of methods of connection are examined in conjunction with various types of voltmeters and different kinds of lamps, and the combinations are tabulated in respect of the sensitiveness attainable. A. J. M.

53. *Constant-speed Railway Motors.* **R. E. Hellmund.** (El. Rly. J. 50. pp. 761–764, Oct. 27, 1917.)—The author discusses the peculiarities of traction motors with a varying-speed characteristic, and with a constant-speed characteristic. By the latter term is meant that if the speed has been adjusted for a certain max. permissible value, it should not inherently decrease whenever the load increases, as, for instance, when an up-grade is encountered. It is thought that this type of motor is likely to be employed to a larger extent in the future. An equipment of this character is heavier and more expensive, but a higher schedule speed can be maintained, which has to be set off against increased fixed charges resulting from a more costly power supply system. While the same weights can be moved with equal energy consumption at either high or low speed, there are increased weights to be moved with the more powerful constant-speed equipment. The various items are considered under the heads of fixed charges, expenses for power generation, labour expenses for transportation department, cost of maintenance and inspection, and expenses caused by lack of reliability of operation. W. H. S.

54. *A Curious Winding on an Asynchronous Motor.* **G. Guastalla.** (Elettrotecnica, 4. pp. 591–592, Nov. 25, 1917.)—The windings of the rotor of an asynchronous 3-phase motor having been burned had been repaired, but as it was not possible to obtain wire of the required section, each coil had been replaced by two coils, the wire employed in these having half the required section. These two coils had to be connected in parallel, but owing to an error the connections were inverted, so that the e.m.f. instead of being nil in the circuit constituted by the two elementary coils, had double the value of that in each single coil. This machine ran as a motor and developed a couple when each winding of the stator was connected in series with each winding of the rotor, these latter being star-connected.

The author gives a demonstration of the working of such a motor, which is equivalent to a motor of which the stator coils are star-connected and each phase of the rotor is short-circuited and insulated from the others, the only difference being that in series with each stator winding is inserted a resistance $\frac{1}{3}r$, where r represents the resistance of an elementary coil of the rotor. E. B.

55. *Voltage-rises due to Third Harmonics in Three-phase Transformers.* **J. Damien.** (Rev. Gen. d'Él. 2. pp. 863–866, Sept. 8, 1917.)—In order to avoid the effects of the third harmonic and its multiples, in three-phase transformers, the following rules are recommended. (1) The load should be

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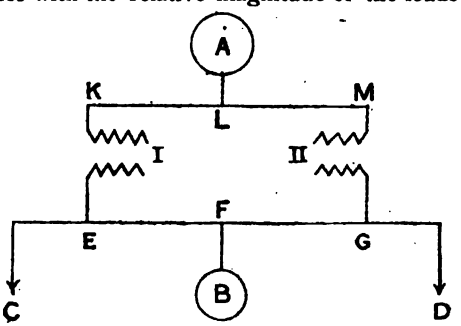
balanced as completely as possible. (2) Three single-phase transformers should be used in preference to a single three-phase, especially for large powers. (3) Delta-connected windings should be employed, on one side of the transformer at least. (4) The neutral points of all apparatus on any system should be connected together so far as possible, without earthing the common junction. (5) The magnetic circuits of the transformers should operate at low saturation. F. T. C.

56. *Parallel Operation of Transformers.* **F. Kade.** (Elekt. Zeits. 38. pp. 493-494, Oct. 11, 1917.)—Transformers generally operate satisfactorily in parallel if their percentage ohmic and inductive drops are the same. In most cases it suffices that the short-circuit voltages are the same. There are, however, cases in which this condition is not sufficient. For instance, if the transformers I and II fed on the primary side by the alternator A supply loads C and D and a second alternator B feeds the secondary side in the position shown in the Fig., then the division of the loads between the two transformers varies with the relative magnitude of the loads C and D. This



case is worked out fully, and the variation in the division of the load is shown to depend on the drop in the leads E-F-G, which may carry the loads in various directions according to the values of the loads C and D. The variation of the distribution of load will be important if the leads E-F-G have a large resistance compared with the resistance of the leads K-L-M. A number of cases of this nature are described, and the conclusion is arrived at that satisfactory parallel operation does not depend solely on the design of the transformers, but that the mode of their connection has an important influence. The division of the loads will become fixed if the loads are taken off on the same side of the bus-bars fed by the transformers. A. J. M.

57. *Insulation of Transformers for very High Voltages.* **A. Still.** (El. World, 69. pp. 312-315, Feb. 17, and pp. 603-607, March 31, 1917. Rev. Gen. d'El. 2. pp. 492-498, Sept. 29, 1917.)—The distribution of electric stress in composite insulators is discussed and some practical rules for thickness of insulation in transformers are given. A layer of air separating two surfaces having a difference of potential E should have a thickness of $(0{\cdot}25 + 0{\cdot}25E \times 10^{-8})$ inches. Oil ducts should not be less than $\frac{1}{4}$ in. wide if free circulation of oil is to take place, and the oil spaces may be divided by sheets of presspahn with advantage—this prevents the alignment of small particles of conducting matter which are liable to cause premature breakdown of the insulating power of the oil. Where an insulation space contains approximately equal thicknesses of oil and of fibrous insulation a thickness of 0·001 in. per 25 volts may be taken. The volts per coil should be limited

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to 5000, and between layers to 400. Creepage surface in air should be $(0{\cdot}5 + 0{\cdot}5E \times 10^{-5})$ inches and in oil $(0{\cdot}5 + 0{\cdot}1 \times E \times 10^{-5})$ inches. For protection against surges an additional reactance at the terminals of the transformer gives the best results. In designing transformer terminals a safe rule for deciding the minimum height is to make it greater than the air-gaps which the test voltage would be able to break down between pointed electrodes. When condenser-type terminals are used there is a tendency for corona to form at the edges of the conducting layers if these are exposed to the air. The corona may be suppressed by surrounding the insulator by a tube of insulating material and filling up the space between them with some suitable compound. It is usual to allow 4000 volts p.d. between adjacent conducting layers. The potential gradient in the air around the insulator can be made more uniform by fixing a large metallic disc at the free end of the terminal, and a spherical extremity under the coil reduces the max. electric stress in the coil. F. T. C.

58. *Effect of Armature Resistance and Reactance on the Terminal Pressures of a Rotary Converter.* **S. Neville.** (Electrician, 80. pp. 267–269, Nov. 23, and pp. 304–307, Nov. 30, 1917.)—In the discussion given here the armature winding is treated as though the number of commutator bars were infinite and the effects of commutation are neglected. The phenomena connected with resistance drop are then investigated by replacing the armature winding by a single endless wire, on which the d.c. brushes slide with polyphase tapping at regular intervals. The value of the resultant current at any point is then expressed as a Fourier series, and the total resistance drop between any pair of tappings or brushes is immediately deduced. For the drop between the d.c. brushes the following expression is given—

$$e_r = IR\left[1 - \frac{8}{\pi^2\eta}\right] - IR\,\frac{8}{\pi^2\eta\cos\phi}\left[\Sigma\,\frac{1}{n^2}\cos(\phi \mp KN\theta)\right],$$

where I = total value of direct current, R = resistance of armature winding, η = efficiency of machine, K is any integer greater than zero, N = number of phase tappings in 360 electrical degrees, $\theta = 2\pi$ ft., and the summation is to include all odd values of n which fulfil the relation $n \pm 1 = KN$. The first term in this expression is the mean value of the drop, which would be registered by a polarised voltmeter, and this is positive if η is greater than $8/\pi^2$, but negative if its value is less than this. The second term represents a ripple of fairly small value, a sample of which is plotted in the original. The instantaneous value of the drop between adjacent phase tapping is given as—

$$e_r = i\mathrm{R}\cdot\frac{4\mathrm{N}}{\pi^2}\cdot\sin\frac{\pi}{\mathrm{N}}\cdot\eta\cos\phi\left[\Sigma\,\frac{1}{n^2}\cdot\sin n\,\frac{\pi}{\mathrm{N}}\cdot\sin n\theta'\right]$$

$$+\,i\mathrm{R}\cdot\frac{4}{\mathrm{N}}\left[\left(\frac{\mathrm{N}}{\pi}\cdot\sin\frac{\pi}{\mathrm{N}}\right)^2\eta\cos\phi\cdot\sin n\theta' - \sin(\theta'-\phi)\right],$$

and the expression for the drop between diametral tappings is—

$$e_r = i\mathrm{R}\cdot\frac{4\mathrm{N}}{\pi^2}\cdot\sin\frac{\pi}{\mathrm{N}}\cdot\eta\cdot\cos\phi\left[\Sigma\,\frac{1}{n^2}\cos n\theta\right]$$

$$+\,i\mathrm{R}\frac{4}{\mathrm{N}}\,\frac{1}{\sin\dfrac{\pi}{\mathrm{N}}}\left[\left(\frac{\mathrm{N}}{\pi}\cdot\sin\frac{\pi}{\mathrm{N}}\right)^2\eta\cos\phi\cdot\cos\theta - \cos(\theta-\phi)\right]$$

In these formulæ i = max. value of alternating current per phase, $\cos\phi$ is the power-factor, $\theta' = \theta + \frac{\pi}{\mathrm{N}}$, and all positive odd values of n are to be taken except unity. An example is given in which the relative magnitude of the fundamental and the ripples are shown. The expression for drop due to true reactance in the winding are shown to resemble the above. F. T. C.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

59. *Propagation of Current along an Open-circuited Line.* **E. Brylinski.** (Soc. Int. Élect., Bull. 7. pp. 217–250, Aug.–Sept.–Oct., 1917.)—It is often supposed that accidents occurring to transmission lines are due to the closing of switches on open-circuited lines. The general solution of the case of a line carrying telephonic currents has been fully worked out by Poincaré, but in a manner offering some difficulty to practical engineers. The special case is now worked out of a line open-circuited at its end and having distributed resistance, reactance, capacity, and leakage. The treatment is purely mathematical and does not lend itself to abstracting. The conclusion is drawn, after examining special cases, that the switching on of an open-circuited line is not attended with danger, as the voltage cannot reach double the normal value and the rise that takes place lasts only for a small fraction of a second. If the line is very long the initial disturbance may last a longer time, but its magnitude becomes very small. A. J. M.

60. *An Artificial High-voltage Line.* **L. Lombardi.** (Elettrotecnica, 4. pp. 560–564, Nov. 5, 1917.)—The purpose of this article is to describe an artificial line constructed by the author for the Naples Electrotechnical Institute. The artificial lines in use at the Zurich Physical Institute, at Union College (U.S.A.), at Harvard University, at the Massachusetts Institute of Technology, and that of the Telluride Power Co. and the experiments made with them, are briefly reviewed.

The line constructed by the author can stand a pressure of some thousands of volts and its characteristic constants can be easily changed. It is formed of three solenoids 86 cm. in diam., each consisting of 108 turns and 1·78 m. long; the wire is of german silver 8 mm. thick. Each solenoid has a resistance of 5·8 ohms and an inductance of 0·77 millihenrys. The capacity for each solenoid is constituted by 12 Moscicki condensers, one coating of each being connected to earth and the others to equally spaced points of the solenoid. The capacity of each condenser is about 0·002 mfd. The total capacity of the line can thus be as high as 0·076 mfd., its inductance 2·4 millihenrys, and its resistance 15·90 ohms. This artificial line is therefore equivalent to a real high-pressure cable some km. in length and of a natural wave-length of about 15 km.

Since for some practical cases the resistance is excessive, other solenoids are being constructed of brass wire, of double the number of turns and of about half the resistance of the former ones. The realisation of other solenoids of copper wire and having a still larger number of turns is also being considered.

The author has employed the artificial line of german silver as a dummy antenna, which allows of measuring instruments (ammeters and spark-gaps) being easily inserted at different points in order to study the conditions of production of stationary waves of the fundamental and higher frequencies. He finally discusses the possibility of employing his artificial lines for studying and comparing the different protective devices for electric lines.

E. B.

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61. *Some Difficulties with Iron-wire Transmission.* **M. D. Leslie.** (El. World, 70. pp. 715–716, Oct. 13, 1917.)—There are some problems still unsolved in the use of long transmission lines of iron wire to serve small loads. The lines here considered both originate from the same transformers in Dodge City (Kan.). One line runs to Bucklin, is 31 miles long, and consists of three No. 6 E.B.B. iron wires 4 ft. apart horizontally on Bates steel poles 300 ft. apart. The other line goes to Minneola, is 22 miles long, and consists of three No. 6 B.B. iron wires, set triangularly 40 in. apart on Franklin steel poles 375 ft. apart. The first line has no transpositions; the other has three, at 7, 14, and 21 miles from Dodge City. Both lines operate at 22,000 volts. It was decided that the max. rating of the line should be about 2½ amps. (primary current) corresponding to an effective resistance on the 31-mile line of 12½ ohms per mile of single conductor, a total rating of 95 kv.a. and 9 % loss. On the 22-mile line the effective resistance was 42½ ohms per mile of single conductor; 95 kv.a. rating, and 6·5 % line loss. Three 20-kv.a. transformers were installed to supply the 50-kw. peak load anticipated on the 31-mile line. Only 15-kw. peak load was expected on the 22-mile line, so this was connected to the same transformers. The only inconvenience from charging current in the older 31-mile line was in creating high voltage at the delivery end. When the second line was connected (later) the switchboard instruments were overtaxed and the transformers overheated. Three 50-kv.a. transformers were then substituted for the original 20-kv.a. transformers, and even these are small for the work they perform. For the 31-mile line alone, the current is 18 amps. per phase on the 2300-volt side with little change of load. With the 22-mile line as well, the current was 38 amps. per phase (later reduced to 30 amps. by connecting two 15-kv.a. transformers which are seldom loaded but furnish some lagging current). The Bucklin line needs about 75 kv.a. on full load, including full-load line and transformer losses. The combined lines require 120 kv.a.

Long, lightly loaded iron-wire transmission lines on steel poles require heavy charging current in proportion to the load they are supposed to carry. Large-capacity ammeters, automatic switches, and transformers are required for relatively small load. This involves high investment; also the line loss is high irrespective of load. Inductive load at the far end of the line would probably improve matters, but the expense of special equipment is hardly justified in such small systems. Iron-wire lines now in use yield a fair return and are employed where copper lines would be commercially impracticable; but one of the difficulties encountered is that the suitability of iron wires for serving light loads at a considerable distance depends on the charging current and not on the load current. R. E. N.

62. *Iron-wire Transmission for Rural Extensions.* **L. P. Perry.** (El. World, 70. pp. 713–715, Oct. 13, 1917.)—A number of standard copper-wire lines in rural districts are unprofitable because the revenue does not even pay the fixed charges on the investment. In such cases or where the line must be taken down after a few years, iron conductors are useful. They cost less themselves and their high tensile strength permits longer pole spacing. No. 6 bare double-galvanised B.B. iron wire is about one size larger and much stronger than the commonly used No. 6 B. and S. weatherproof copper wire and has not to carry a load of weatherproof insulation. Iron wire on poles 250 ft. apart to give 6 ft. sag is much stronger and more likely to retain its original length and position than copper wire usually erected on more

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closely spaced poles. The risk from rusting is considered to be small. Small iron telephone wire is safe for 10 to 20 years, and the larger size proposed for transmission purposes will, of course, have less exposed surface per unit weight. Again, accidents rarely occur due to rusting of stranded, galvanised iron wire used to suspend 600-volt trolley wires.

Using No. 4 iron conductors with an 18-ft. clearance above ground, the cost of 85-ft. poles works out 6 % cheaper (per mile) than that of 80-ft. poles. Data in the original show that it is no more expensive to use No. 4 conductors with long spans than smaller wire with shorter poles. Poles on the 18,200 volt, 3-phase line to Lyman Viaduct are 85 ft. long and set 275 ft. apart on tangent right-of-way. The poles carry one No. 4 bare, medium-hard-drawn copper wire and two No. 4 double galvanized B.B. iron wires. The wire joints are made with copper sleeves. The conductors are tied to the insulators with galvanised iron wire, and special care was taken during erection to avoid damaging the galvanising of the conductors, so as to permit rusting. By cutting the poles 5 ft. longer than usual an extension is provided at the top to carry the ground wire. This makes it unnecessary to use an angle-iron bayonet, which is more costly and less strong. Tables of sags for iron conductors under various conditions are given in the original. R. E. N.

63. *Line Drops and Rail Potentials reduced by 3-wire System.* **E. H. Hagensick.** (El. Rly. J. 50. pp. 850–852, Nov. 10, 1917.)—The 3-wire system has been adopted in Omaha as the result of the recommendation of the United States Bureau of Standards, which dealt with the case as the result of troubles arising from electrolytic damage. This article contains an account of the methods which were adopted to effect the change. A plan of the town is also given. The result is that the voltage-fall in the track has been much reduced, as has also been the case with the current passing through the water-pipes. In one place the current through a water-pipe has been reduced from 118 to 13 amps. Thus there has been a considerable reduction of the line losses in the return circuit, resulting in an increased voltage on the cars; a reduction in the over-all potentials and potential gradients with corresponding reduction of current on all pipes and underground structures; and a reduction of potential differences throughout the entire district. W. H. S.

64. *Transformer Losses in Large Rural Distribution Systems.* **H. Roth.** (Elekt. Zeits. 38. pp. 501–503, Oct. 18, 1917.)—Two systems are compared. In the first the energy is transmitted and distributed at 20,000 or 30,000 volts; in the second the energy is transmitted to transformer stations at 30,000 to 50,000 volts and distributed at a lower pressure, say 6000 volts. Small transformers for lower primary voltages have much smaller iron losses than those for the higher voltages. The additional transformer capacity which must be installed is only about one-half of the total capacity of the consumer transformers, and if this capacity is made up in two or three units one or more can be cut out during periods of light load. Thus in spite of the additional transformers the total losses may be less in the second case than in the first. As an example the author considers a case in which the total connections amount to 12,000 kv.a. and the average capacity of the individual transformers is 25 kv.a. Intermediate transformer stations totalling 6000 kv.a. are installed. The transmission line voltage is 30,000; if the distribution voltage is 20,000 there are to be two transformer stations, and if 6000 then 12 intermediate stations, with three transformers in each. Comparing with the case in which transmission and distribution is carried out at one voltage,

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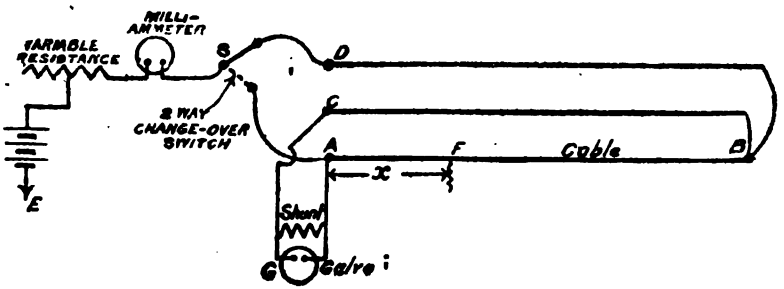
viz. 20,000, and allowing for the extra copper losses in the intermediate transformers, it is shown that when the distribution voltage is 20,000 the intermediate transformers increase the losses by about 20 %, but when the distribution pressure is only 6000 volts the losses are decreased by 4 %.
F. T. C.

65. *The Improvement of the Power-factor.* **G. Sartori.** (Elettrotecnica, 4. pp. 570–575, Nov. 15, 1917.)—The author calculates that about 80,000 kw. are lost in Italian electric lines because of the low power-factor. Its improvement is, therefore, of great economic importance, especially at the present time, as the energy available for war work is far from being excessive. The author examines the different solutions given to this problem, such as static condensers and the Kapp, Scherbius, and Walker machines, and demonstrates that in all cases it is economically advantageous to employ phase-advancing devices. The conditions under which the one or the other of these devices must be employed are briefly discussed. E. B.

66. *Fault Localisation by Drop of Potential.* **H. E. Blake.** (El. Rev. 81. pp. 172–178, Aug. 24, 1917.)—In utilising the drop of potential method, the ideal conditions for success are indicated by the following diagram :—



Suitable readings on G are obtained by adjusting the resistance. Then $x = l \times d_1c_2/(d_1c_2 + d_2c_1)$.

x = distance of fault from A, l = length AB.
d_1 = galvo. deflection with S to A
d_2 = " " S to D
c_1 = milliamps. with S to A
c_2 = " " ... S to D
} Without altering galvo., shunt, or variable resistance.

The errors eliminated by this method of connection are those due (1) to fault resistance, (2) to the loop at the far end B, (8) to cable connections to the apparatus. The method has advantages over Murray and Varley loop tests. Faults on short lengths of distributor may be localised by laying a twin c.t.s. cable in the gutter to represent the two testing lines. Applications of the test to variable fault resistances, to feeder breakdowns, and to faults when only one sound line is available are detailed. Faults on cables laid solid in wood troughing are often caused by the turpentine in the knots acting as a solvent for the bitumen. W. E. W.

67. *Protection of Cables against Electrolysis.* (Annales des Postes, Télég. et Téléphones, 6. pp. 225–237, June, 1917. Electrician, 79. pp. 988–989, Sept. 14, 1917. Abstract.)—The article outlines the simple principles of electro-

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lysis as occurring in underground cables, and deals with the causes, tests, and instruments to be employed in its detection. The use of leakage-conductors is desirable when a positive potential with regard to earth exists over the greater part of the network. Sometimes small sections of cable situated in the vicinity of conduits, metal bridges, or earth saturated with sea-water, are exceptional in being positive with regard to earth, the adjacent good conductors deriving from outside the cable a large portion of the current carried to the spot by the cable in question and then by returning it again re-establishing a negative potential. In such a case the expense of installing a leakage-conductor may be avoided by isolating the negative portion of the cable from the rest of the network, the continuity of the armour covering being preserved by running an insulated conductor parallel to the disconnected section. Some such arrangement will be desirable whenever similar circumstances give rise to a pronounced local negative potential—an effect which reacts on other parts of the network and is extremely difficult to overcome. It is not always necessary to preserve continuity of the sheath, and the connecting bond may sometimes be dispensed with. Electrolysis is the consequence of contacts established between cables and moist soil. As such a medium is almost omnipresent, it is desirable to reduce contact of sheath and soil to a minimum. To insulate a cable completely from the earth is an operation requiring considerable care and expense. The conduits commonly employed are sufficiently good protectors, but experience has shown that even so it is impossible completely to avoid contacts between sheath and earth. The proper installation of conduits is the best means of reducing the possibility of such contacts to a minimum. Well-designed and supervised junctions should avoid interruption of alignment, and suitable conduits, kept clean and preserved in cement may be recommended. The position of a cable needs careful initial supervision. It not infrequently happens that corrosions occur before any precautionary steps have been taken. An initial survey of the district by a person acquainted with electrolytic problems will determine whether preventive measures should be taken at the time the installation is made. W. E. W.

68. *Graphical Presentation of Electrolysis Data.* **H. A. Cozzens, Jr.** (El. World, 70. pp. 614–616, Sept. 29, 1917.)—A detailed description of several methods of recording investigations as to the electrical potential of cable sheaths with respect to surrounding water and other pipes and metal structures, with a view to recommending remedies such as new or additional bonds, negative returns, etc. One method is the indication on a large map or sectional maps, of the polarity of the cable sheaths by bands of colour, and of their potential by the width of these bands; the maps being of the area of the distribution or railway feeder system. Another method is to use similar maps with polarity indicated by the colour of the dots and potential by figures, a datum or base line being drawn through the centre of each street. In another method the routes of feeders or distributors are laid out at the foot of a chart the vertical lines of which read in volts; above the route plan curves are drawn showing the potential relationship of the cables to various surrounding water, gas, and telephone constructions. Such a chart shows at a glance the p.d.'s of all structures and any abrupt changes can be analysed. It is also useful to take current records over a period of time and plot these readings over the same period as the max. load curve, on the same chart. Examples of each of the suggested methods are given. W. E. W.

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69. *Parallel Operation of Distribution Transformers.* (El. World, 70. p. 845, Aug. 25, 1917.)—A description of a special protective device to admit of the operation of distribution transformers in parallel. It comprises a fuse of 0·0006-in. copper $\frac{7}{8}$ in. wide, sheared into 5 equal parallel strips, each strip having a carrying capacity of 75 amps. The strips not required are broken out by the linesmen or, conversely, additional links are installed on top of each other to the required carrying capacity. The fuse is installed on a special jumper formed of a standard strain insulator with arms of 0·75-in. cast brass, attached to the line by clamps having two $\frac{3}{8}$ in. by 1-in. sherardised cap screws. The fuse is held between the jumper arms by brass cap wing-nuts to admit of quick renewal. The Northern States Power Co., Minneapolis, Minn., uses a 4000–2300/220–110 volt transformer for each section of network, spacing them to suit the load. The primary main comprises interconnected rings and no more than a single transformer is connected to any branch outside the ring system. With a properly designed ring system the secondary leads by-pass the load round a primary break. The fuses described cost 7 cents and the holders $2.25. W. E. W.

70. *The Calculation of Iron Poles.* **A. Barbagelata.** (Elettrotecnica, 4. pp. 528–529, Oct. 15, 1917.)—The author sets forth the principal points of the calculation of iron poles for electric lines, upon which opinions do not agree, in order that they can be examined and discussed by the members of the Associazione Elettrotecnica Italiana, chiefly in view of the compilation of the "Rules for the Construction of Aerial Lines," which the author wishes to be fixed by the A.E.I.

The factor of safety for the iron is generally assumed much higher than that in constructions of different order, as, for instance, for the insulation of electric machines, where the temperature of the insulating substance is allowed to reach 100°, whilst at 110°–120° it begins to be altered.

The "ordinary" and "exceptional" conditions to which the poles can be subjected are rather arbitrary. "Ordinary" conditions are generally considered to be those to which a pole is subjected at the lowest admissible temperature, and when the wires are loaded with snow or ice and the direction of the wind is at right angle to the bundle of wires. But since the max. stress upon the vertical irons of a pole is obtained when the direction of the wind makes an angle of about 30° with the perpendicular to a face of the pole, the "ordinary" pull of the wind which is what is generally considered, is less than the maximum, which latter can be produced as easily as the former. "Exceptional" conditions are considered to be those arising from the partial or total rupture of the wires of a span. The author thinks it excessive so to calculate the poles that they could stand the stresses resulting from the break of all the wires of a span.

The properties of the two types of masts, the "lattice" and the "tubular," are worth discussion, as opinions differ considerably as to their respective advantages and inconveniences.

For the calculation of the members of the pole, the constructors do not agree in considering some of them as mortised and others as simply pivoted at their ends. As in the former case the section works out at half that required in the latter case, the matter is worthy of being discussed. Other uncertainties as to the manner of considering other parts of lattice masts are indicated by the author.

As to the method of calculation of poles of minimum weight, the author

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agrees with Semenza [Abs. 802 (1917)]. He limits himself to some considerations which allow of explaining physically the conclusions of Semenza, and gives some curves for practically finding the characteristics of the poles of minimum weight.

In two notes at the end of the article, the author sets forth a method of calculation of the stresses acting on the different members of a pole. E. B.

71. *The Calculation of Iron Poles.* **A. Stura.** (Elettrotecnica, 4. pp. 607–609, Dec. 5, 1917.)—The author demonstrates that in a lattice pole the almost vertical irons cannot bend in any other plane than that of a face of the pole, since the nodes between vertical irons and diagonals are alternate in two adjacent faces of the pole, and that the diagonals must be considered as simply pivoted at their ends if they bend themselves in the plane of the face pole to which they belong, and as mortised if they bend in the other planes; and since the former hypothesis is the most unfavourable for the resistance of the diagonals, it follows that both the vertical irons and the diagonals must be considered as pivoted at their ends and as bending in the plane of a face of the pole. Consequently, the formulæ of Euler and of the Italian Railways, which assume these irons to be pivoted at their ends and that they can bend in all planes, lead to too large sections of iron and to a waste of material.

The author considers the graphic method of Kuhlmann to be convenient for the calculation of the stresses acting upon the members of a pole. E. B.

72. *Economic Importance of an Overland Central Station for Luxemburg.* **J. P. Manternach.** (Elekt. Zeits. 38. pp. 373–376, July 19; 385–387, July 26, and pp. 403–406, Aug. 9, 1917.)—The author examines in detail the present state of power development in the Grand Duchy and its possibilities under a comprehensive overland central station scheme.

In a total of 1706 existing installations there are 467 steam plants (15,944 h.p.); 726 gas (5087 h.p.); 431 water-power (3122 h.p.); and 650 electricity (5374 h.p.). There are 539 agricultural installations averaging 6·2 h.p. each; and 493 installations in foodstuff industries, averaging 9 h.p. each. The max. average in this classification is 122 h.p. each in 31 stone-getting and stone-working installations.

The second portion of the paper is devoted to an estimate of the probable load on an overland system. Tramways in the capital use 384,000 units per annum, and proposed light railways and tramways in the Esch canton would use about 1,542,000 units per annum, but in both cases an overland station would have to compete with supply from colliery power-houses. The author discusses in detail the reasons why prospects for lighting businesses are unfavourable in this district. The present consumption for electric lighting is less than 500,000 units per ann., two-thirds of this being in Luxemburg and Esch; under the most favourable circumstances the total for the whole country could hardly exceed 2 million units per ann. If an overload station be established, it must encourage electric lighting by every means possible.

The probable connected load would total 9850 kw. made up as follows:—Lighting 1920 kw.; heating and cooking, 160 kw.; agriculture, 750 kw.; small industries, 750 kw.; medium and heavy industries, 3800 kw.; traction, 500 kw.; line loss, 1970 kw. A 10,000-kw. station would suffice; the load factor would be poor at first, but should soon improve. Use might be made of water power, of steam- or oil-engine plant, or of energy purchased in bulk and distributed.

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The most economical solution would be for the overland station to take energy in bulk from ironworks. A suitable transformer station would cost £19,850 and the distribution network £178,500. The fixed annual charges would be £19,400, and 3-phase energy at 5000 volts should be obtainable from ironworks, etc., at 0.305d. per unit on 10 million units per ann., or 0.275d. on 80 million units per ann. The corresponding total costs would be 0.77d. and 0.428d. per unit respectively.

Finally, the author discusses the relative advantages of private, municipal or State, and mixed control. R. E. N.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

73. *The Vienna Municipal Electricity Station in* 1915–16. (Elektrot. u. Maschinenbau, 35. pp. 441–446, Sept. 16, and pp. 457–462, Sept. 23, 1917.)—During 1915–16 the Vienna electricity undertaking had to work subject to the military requisitioning of metals; during the preceding year much copper and lead was released in the course of taking over and re-equipping the plant of the Allgemeine Österreichische Elektrizitätswerke. This reconstruction work was completed during 1915–16 despite the difficulties to be overcome. A 3000-h.p. triple-expansion engine, generator and auxiliaries at the Simmering I station was replaced in about 8 months by a 12,000-h.p. turbo-set. The principal work at Simmering II station was the construction of a barracks for prisoners of war and interned aliens who were employed in place of some of the usual workmen. A similar barracks was erected at Engerthstrasse, where also the installation of a Garbe boiler (500 sq. m. heating surface) was completed and a fifth induced-draught fan was installed (capable of dealing with 4000 m.³ per min.). The coal-handling plant has also been improved. By sacrificing some storage batteries in substations and redistributing others; about 407 tons of lead and plate materials were liberated for military use. The Mariahilf substation and other equipment was converted from underground to overhead distribution without interrupting operation. In order to meet increased lighting and power demands on the Rudolfsheim substation caused by the war, without making fresh demands on material and labour, a 1000-kw. converter has been taken from the Kaunitzgasse substation. Batteries taken by the military are to be replaced by equivalent batteries within 1 year from the conclusion of peace. A 294-cell, 7776 amp.-hr. battery not hitherto used has been placed in commission in the Kaunitzgasse substation to deal with this winter's load; this is the largest battery yet in use in Austria-Hungary. The 4 × 110-volt network of the A.O.E.G. is connected to a feeder panel in the Alsergrund substation and by rearranging the feeder system a certain amount of metal has been released for military use. The old Neubad steam station is now a converter substation and this reconstruction has liberated a good deal of copper and lead from disused cables. The bus-bar and distributing system in the Vosendorf substation is made of iron.

Owing to the requisitioning of copper and lead, the cable network has been extended only by a few distributing lines, most of these being for military purposes. By agreement with the Ministry of Railways, the station installations of the Vienna Stadtbahn, and the Franz Josephs and West stations were connected to the municipal electricity works. The connected load of these 58 installations amounts to 650 kw. direct current, 899 kw. 3-phase, and 91 kw. single-phase alternating current. Between March 1915 and the end of 1916, about 490 tons of copper and 330 tons of lead were released by removing

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cables not used under the new scheme. A lead-sheathed and armoured cable of 1000 mm.² copper section formerly connecting the Ober Donaustrasse station to the Neubadgasse substation was pulled to pieces and its 6-mm. wires were drawn down to 2·1 mm. diam. and re-stranded to form conductors for the Ebenfurth-Vienna h.t. overhead transmission. Up to June 30, 1916, half-watt lamps of 1500 c.p. had been substituted for 110 arcs in public lighting.

During 1915–16 there was a net increase of 54 transformer installations on the 3-phase network and 36 on the single-phase network, making the total number of 3-phase and of single-phase installations 810 and 2190 respectively. On June 30, 1916, there were 1077 transformers (67,202 kv.a.) on the 3-phase network, and 2612 transformers (28,452 kv.a.) on the single-phase network. There was a net increase of 5823 in the number of meters, bringing the total up to 136,184. Tables in the original show the number of filament lamps and arc lamps and the number of power installations and the connected load in each case, classified according to the industry or application concerned. These data relate to so many installations and are so detailed that they are very useful for estimating.

The overland transmission line from the Ebenfurth power station to Vienna was not completed and put into service until Dec. 1916 but much work was done in connection with this scheme during the year 1915–16. A coal-handling plant was installed to carry brown coal from the Zillingdorf colliery to the power-station bunkers in self-emptying trucks running on a narrow-gauge railway. About 40 tons per hr. is normally delivered to the boiler-house, but this delivery can be doubled. Coal is taken from a preliminary dump to a jigger screen which passes the small pieces and delivers the rest to a breaker. Broken coal is lifted to a hopper which feeds the buckets of an electric suspension conveyor running to the boiler-house. Each bucket or car holds about 1 ton and has a small motor for its propulsion. The actual load is determined by an automatic weighing machine. Preparation was made during the year for the installation of two 12,000-h.p. turbines, four Garbe boilers (500 m.² heating surface), an electrically driven feed pump and other auxiliaries, pipes, etc.

Exceptional difficulties had to be overcome in erecting the 70,000-volt line from Ebenfurth to Vienna. Delivery of the lattice masts was much delayed and the shortage of wagons made it difficult to obtain delivery of cement and ballast for foundations. Interned Italians were employed to make good the shortage of native labour. A total of 125 tons of copper is used in the two 3-phase lines, part of this metal being derived from disused A.O.E.G. cables and the whole being sanctioned by the military authorities in view of the importance of the service.

The 16,000-volt overland network was extended considerably during the year. An agreement was made with Baden and Pottendorf under which these places are to take supply from the Vienna overland network. This will liberate considerable quantities of copper and lead besides securing operating economies. In order to supply Baden, the Ebenfurth–Engesfeld overhead line had to be extended about 12 km. to Leesdorf, where a transfer station is provided for connection to underground cables. The Voslau network will be connected to the Engesfeld–Leesdorf line as soon as completed, and the Vienna–Baden Lokalbahn power station is to be shut down after the war and current then taken from Leesdorf substation. An overhead line supplies Pottendorf from Ebenfurth and is extended to supply a munitions works at Weigelsdorf. A reserve supply is carried to the Neufeld mines over part of the same route. It is proposed to run a 35,000-volt line from Ebenfurth to

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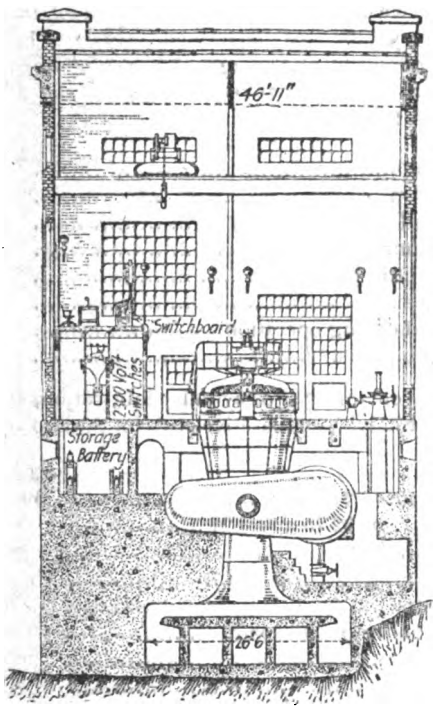
Kottingbrunn, connecting through a transformer station to the Engesfeld–Leesdorf line. There is a great demand for power between Vienna and Ebenfurth but it cannot be met under present conditions of labour and material supply, especially in view of the fact that the primary duty of the Ebenfurth station is to relieve the Vienna plant. The complete overland network includes 14 transformer stations with 29 transformers and a total rating of 24,910 kv.a.

Six large tables in the original analyse in considerable detail the equipment of the main and substations in the complete system; the working hours and output for the year; the connected loads and the demands for various purposes. R. E. N.

74. *Features of Hiram Falls Development.* (El. World, 70. pp. 658–661, Oct. 6, 1917.)—A detailed description of a hydroelectric development of 20,000-kv.a. ultimate capacity on the Saco River by the Cumberland County Power and Light Co., Portland, Me. The first section includes a 8000-kv.a.



unit driven by a 4000-h.p. vertical wheel under 75 ft. head, the water being introduced at the low velocity of 4 ft. per sec., and controlled by a butterfly valve operated by a 8-h.p. 125-volt induction motor. The feature of the installation is the use of a White hydraucone regainer in place of the usual draught tube. The construction is shown int he cross-section of the power-house in the Fig. This hydraucone is stated to increase the efficiency of the turbine about 2 % above the 89 % named in the contract. It consists of a specially shaped discharge chamber, with reinforced concrete slabs placed horizontally and vertically so as to secure the most efficient disposal of the water leaving

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the wheel. The tail-water can be discharged direct to the river when inspection of the hydraucone is needed. The station equipment follows standard lines. There is a 66,000-volt bus-bar and switching structure outside the generator building. W. E. W.

75. *Savings in Remodelled Plant.* (Power, 46. pp. 682–686, Nov. 20, 1917.)—The Rockwell Manufacturing Co., Milwaukee, makers of mill work (wood) for building construction, have made a large saving in working expenses by modernising their power plant. The old plant consisted of a simple Corliss engine with cylinders 30½ × 60 in., jet condenser, and six boilers, 490 h.p. in all, driving hundreds of feet of line shafting. The new plant comprises a 875-h.p. poppet-valve engine running at 150 r.p.m. with steam at 150 lbs. pressure and 100 deg. F. superheat, against 8·5 lbs. back pressure driving directly a 812-kv.a., 3-phase, 63-∿, 220-volt generator. The distribution is on the 3-wire system to motors of 718 total h.p. and lighting. The steam consumption is less than the guaranteed 18 lbs. per i.h.p.-hour. The exhaust steam is now used for all drying and heating, formerly done by live steam. Two boilers, each of 1250 sq. ft. heating surface, using wood waste as fuel, have replaced the old six boilers, and very little coal is burned. Cylinder lubrication is effected with high grade oil supplied through a power pump driven from the lay-shaft of the engine. The power requirements of the new and old systems are compared thus :—

	Old, H.P.	New, H.P.
Line shafting	168	0
Blower system	196	80
Constant load (shaft and fans)	359	80
Machines running idle	134	0
For actual cutting operation	69	69
Variable load	203	0
Average load during operation	562	286
Steam per i.h.p.-hour	22 lbs.	18 lbs.

Tables are also given for cost of cylinder lubrication, and of operating data for 12 months separately. Comparative costs for the two systems are tabulated thus :—

	Old (1913).	New (1916).
Coal, 3498 tons at $2.65	$9270	—
471 „ at $2.75 and 3.25	—	$1435
Wages	4986	—
Water	498	—
Boiler repairs	758	—
Boiler and entire plant repairs	—	902
Belt repairs	585	266
Oil and waste	310	114
Boiler compound	87	20
Packing	40	0
Boiler insurance	62	55
Miscellaneous	0	75
Total operating	16,546	6162
Fixed charges, 15 % on $9500	1425	—
15 % on $29,129	—	4369
Total	$17,971	$10,531

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The saving due to covering the steam pipes with asbestos, millboard, and magnesia section is discussed in detail. W. N. Y. K.

76. *Electric Drive for Battleship "Tennessee."* (Power, 46. pp. 172–173, Aug. 7, 1917.)—The super-Dreadnought U.S.S. *Tennessee*, displacement 32,600 tons and max. speed 21 knots, will be driven by four 3400-volt motors, each developing 6700 h.p. at 175 r.p.m., on the four-pole connection, and 2135 h.p. at 118·8 r.p.m. on the 86-pole connection, and 8375 h.p. at 185 r.p.m., for 4 hours. The energy for the motors will be furnished by two Westinghouse standard alternators each rated at 13,500 h.p., driven by impulse-reaction semi double-flow turbines; the h.p. steam will be expanded in suitable nozzles, passing through a two-impulse wheel, then through the first single-flow reaction expansion, and then through a second expansion which is double-flow. The guaranteed steam consumption will range from 15·45 lbs. per shaft h.p., speed 10 knots, propellers 81 r.p.m. and 2600 s.h.p. developed, to 11·9 lbs. per s.h.p., speed 21 knots, propellers 175 r.p.m. and 26,800 s.h.p. developed. The motors will operate as wound-rotor machines, 24-pole connection for starting and reversing and as squirrel-cage machines, 86-pole connection for running. The insulation used will be mica only, with fibrous material only for securing windings in position. The construction adopted will permit the temperature to be raised to 300 deg. F. without injury. Liquid rheostats will be used, giving a fixed rate of acceleration, and the motors can be started singly or in groups, and also reversed quickly. Both turbo-generators and motors will be under the control of a central control room communicating with the bridge. To furnish power for lighting, heating, cooking, and motor drives on board the vessel six 300-kw. geared d.c. turbo-generators will be installed. Similar equipment is being supplied for the new battleships *Colorado* and *Washington* now under construction. W. E. W.

77. *Re-engineering an Interurban Line.* (El. Rly. J. 51. pp. 612–616, Oct. 6, 1917.)—The Fort Wayne-Decatur line, 22 miles long, was intended to form part of a 150-mile line from Fort Wayne to Springfield. It was arranged for single-phase alternating current at 6600 volts, 25 ∿, and a 680-h.p. cross-compound Buckeye engine was installed to drive a 450-kw. generator. Provision was made for two units but only one was installed, and that operated at such poor load-factor (with only one car on a 3-hr. schedule) that the guarantee of 14 lbs. steam per kw.-hr. was never reached. The cars made only 11,000 miles a month with an energy production of 30,000 units a month. The cost of power was from 6·3d. to 5d. per car-mile excluding overhead expense and line loss. It was impossible to work profitably with the "misfit" equipment, which has now been changed entirely.

The line is now operated by direct current at 1200 volts. There is a single substation at the centre of the route. New substations have been built to utilise energy purchased in bulk from Fort Wayne. The old power-house and cars were scrapped, but the old catenary overhead system and its messenger cable are retained. The second rail has been bonded, the lightning arresters readjusted and redistributed, and the earth connections renewed.

The step-up substation just outside Fort Wayne, and the rotary converter substation are the first to be built in complete accordance with the Bureau of Standards safety code. The additional building cost due to the liberal clearances demanded by this code is insignificant in stations of this size. The step-up station contains three 150-kv.a. transformers for

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4000/88,000 volts. The converter substation contains three 88,000/390-volt transformers and two 220-kw., 600-volt rotary converters connected in series to yield 1200 volts line pressure. Connection is made to the trolley wire 5000 ft. on either side of the substation, this arrangement being chosen because it provides resistance between trolley connection and converter, to reduce voltage variations. Transformers are connected in star at the step-up station and in delta at the rotary substation, with the neutral grounded at substation only; this permits a grounded line to be used as system ground.

The old single-phase cars weighed nearly 90,000 lbs. each; the new cars, for a 1½-hr. service, weigh only 59,100 lbs. each, made up of: Body, electrical equipment, and air brake, 32,600 lbs.; trucks, 15,900 lbs.; motors, 10,600 lbs. The cars are geared for 45 miles/hr., and all cars have a change-over switch for operating on 600 volts supply in Fort Wayne; this is a master-switch controlling lighting, air compressor, and all other equipment by means of a specially designed apparatus. Each car seats 46 passengers; details of construction are given in the original. The new cars have resulted in 50 % saving in energy consumption. R. E. N.

78. *A New Electric Mine Hoist at Butte, Montana.* **R. S. Sage.** (Am. I E. E., Proc. 36. pp. 573–588, July, 1917. Electrician, 80. pp. 74–77, Oct. 19, 1917. Abstract.)—The number of Ward Leonard and Ilgner-Ward Leonard hoist equipments which will have been put into operation during 1916 and 1917 will equal the total number operating prior to 1916 and the aggregate h.p. capacity will be 50 % greater.

A recent Ilgner-Ward Leonard hoist installation, which is one of the two largest of this type in operation in America, is installed at the Elm Orlu Mining Co.'s mine at Butte, Montana. The shaft is sunk to 1800 ft. and will ultimately be taken down to 8500 ft. The general characteristics of the hoist are as follows:—

VERTICAL SHAFT.

Present max. lift	1800 ft.	Diam. of rope	1·5 in.
Ultimate „ „	8500 „	Weight of rope per ft.	8·55 lbs.
Weight of skip and man cage	11,000 lbs.	Max. speed of skip during hoisting	2500 ft. per min.
Weight of ore per trip	10,000 „	Diam. of drums	10 ft.
Weight of rope (8500 ft.)	12,500 „	Max. hourly tonnage (of 2000 lbs.) 8500 ft. level	155

The hoist consists of two 10-ft. diam. steel-plate drums, grooved to hold 1900 ft. of 1·5-in. steel cable per layer, and mounted on a single shaft between three bearings. The brakes are released and the clutches operated by means of oil, through cylinders with floating-level control, served by an oil accumulator in connection with a motor-driven triplex oil pump. To the drum shaft is coupled an 1800-h.p., 80 r.p.m., 525-volt d.c. motor having 16 poles and also commutating poles. The motor receives its power from a set consisting of generator, induction motor, and flywheel. The generator has a continuous capacity of 1500 kw. It is equipped with commutating poles, and in addition a compensating winding is placed in the pole-faces of each of the 12 main poles. The exciter for generator and main motor is wound for 125 volts. The induction motor is rated at 1150-h.p., 3-phase, 60 ∿, 2200 volts, synchronous speed 514 r.p.m. It has a wound rotor with

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collectors for connections to the automatic slip regulator. The flywheel is built up of thick steel plates 11 ft. 10½ in. diam., so that the peripheral speed is 19,100 ft. per min. at synchronism. The total weight is 92,000 lbs. exclusive of shaft. The wheel is coupled to the generator by a Francke-type flexible coupling. Lubrication is afforded by means of a low-pressure oil pump, supplemented by ring oiling. The oil is water-cooled. To reduce the demand on the power system, when starting the set, a small motor-driven high-pressure oil pump is provided to supply oil pressure under the bearings. With this pump in operation, the set starts from rest with 80 % of full-load. For particulars of the method of control the original paper must be referred to.

Tests.—The first set was for the purpose of analysing a typical day's run. The total energy used, including non-productive work per ton of ore hoisted was 5·94 kw.-hrs. with an average lift of 1428 ft. The second test was made hoisting as rapidly as possible from 1574·5 ft., with the following results :—

Weight of ore hoisted per trip,	4·06 tons	Average time running full speed per trip	15·5 secs.
Average time per trip	118 secs.	Average time for retardation per trip	24·5 „
Average running time per trip	62 „	Average rope speed,	1525 ft. per min.
Average time at rest per trip	51 „	Max. rope speed,	2580 „ „
Average time for acceleration per trip	22 „	Kw.-hrs. per ton	2·49
		Mechanical efficiency of hoist	83 %
		Over-all efficiency.....	47·7 %

The power input to the motor-generator set running light at 512 r.p.m. is 80 kw. F. R. C. R.

79. *The Vamma Power Station, Norway.* (Engineering, 104. pp. 187–189 and 150, Aug. 10, 1917.)—A brief description is given of the development of hydroelectric generating stations in connection with the Glommen River, which has the largest flow of all the Norwegian rivers. Its length is 810 miles and the catchment area 16,100 sq. miles. The Mjösen lake, 140 sq. miles, forms a natural reservoir of great capacity, 800 million cub. m. of water, and secures a minimum flow of 200 m.³ per sec. The Hafslund Co. has a power station of 25,000 h.p. and the Kykkelsrud plant can develop 46,000 h.p. At the Vamma Fall the power station was commenced in 1915, and the aggregate capital now invested in the three power systems is £2,880,000. The head is 27 m. and the concrete dam is 280 m. long, with 15 intake sluice valves at the upper ends of the turbine supply pipes. A plan and sectional elevations show the construction of the station, designed for 15 units of 12,000 h.p. each; six of these are now provided for, with two 500-h.p. auxiliaries for separate excitation. The generators are entirely cased in, and the rotors are fitted with fans drawing air either direct from the open or mixed with warm air from the machinery hall. The heated air is forced into the basement and then through different channels for heating the power-house, inspection tunnels of the dam, or oil pressure installations of the throttle valves. The generators can be run in three independent groups. All auxiliary power is supplied by 8-phase current. Power is generated at 5000 volts and transformed up to 50,000 volts. Excess-voltage protection is afforded by horns in star-triangular coupling with oil resistances. "Repelite"

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has been used throughout as insulation to the exclusion of porcelain. For 50,000-volt circuits copper and brass tubes 80 mm. and 20 mm. in diam. and 1 mm. thick have been used. W. N. Y. K.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

80. *Electric Traction with Accumulators.* **R. Vallauri.** (Elettrotecnica, 4. pp. 534–543, Oct. 25, 1917.)—The author makes a numerical comparison between the costs of an electric tramway worked with accumulators and another with aerial trolley wire, and finds that only in the case of a very low traffic, *i.e.* of not more than one departure every ¼ hour, can the former system compete with the latter. Moreover, the max. "radius of action" of an accumulator tramway is, in the actual state of development of the cell, very limited and rapidly diminishes, when even small gradients are to be taken into account. For instance, for a mean gradient of only 2 in 1000 the "radius of action" aforesaid is reduced to 66 % of that on the level. The limitation of the radius of action necessitates the installation of a large number of sub-stations for recharging the accumulators, so that the cost of the aerial line feeding these substations would represent a substantial fraction of the cost of the overhead line of a trolley tramway.

In conclusion, only in one case can accumulator traction compete with or be preferable to trolley traction, namely, in the case of a very low traffic and limited "radius of action." Many numerical examples and calculations are given by the author for demonstrating some points of the comparison. E. B.

81. *Storage Battery Locomotives in Coal Mines.* (El. Rev. and West Electn. 71. p. 548, Sept. 29, 1917.)—Figures are given as found by the Madison Coal Corporation for operation with mules and storage battery locomotives respectively. In gathering coal and for main haulage in coal mines, the cost in the case of mules, allowing a life of 5 years per mule, is $0.04096 per ton. In the case of storage battery locomotives the corresponding cost, including current at ¾d. per unit, is $0.02099. Maintenance of batteries and of equipment is included, but depreciation appears to be excluded. Some other figures are given in regard to the Pocahontas Smokeless Coal Co. W. R. C.

82. *Three Electricians for the Maintenance of Twenty-eight 2400-Volt D.C. Locomotives.* (El. Rly. J. 50. pp. 716–717, Oct. 20, 1917.)—This paper describes the experiences of the Butte, Anaconda and Pacific Railway in maintaining their 2400-volt d.c. locomotives since 1913 under very arduous conditions. This railway was the first to show that such locomotives deal with very high tonnage, and it is doubtful whether any other railway has such a heavy freight service. A train of 75 ore cars, each weighing 68 tons or more, is often hauled from Butte. During May 1917 the average load west was 4456 tons on an average grade of 0·8 % (0·6 % max.). The average empty train eastward was 1519 tons. Loaded trains are run up to 15 miles/hr. The same locomotives geared 28 : 80 instead of 18 : 87, give 55 miles/hr. max. speed on the 26-mile passenger run (Butte–Anaconda). Trains are run 120 and 168 miles on alternate days. The G.E. locomotives are run singly for passenger service and in tandem for freight; the freight locomotives weigh 82 tons, the

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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others 80 tons each. Three tractor trucks are used; each weighs half as much as a locomotive, and when connected in series with a single locomotive gives 50 % more tractive effort in switching and spotting service at ½ reduction in speed. The use of these trucks saves abusing resistor grids. Each of the 8 motors per double unit is rated on the hourly basis at 320 h.p.

Two electricians and one helper attend to all maintenance on the 28 locomotives and three tractor trucks, including the car heating and lighting, and the power, heating and lighting of the steam-electric locomotive and car shops. The maintenance crew does all re-winding, and only one commutator has ever been sent to the factory. The number of machinists for mechanical maintenance is less than half the number needed for all-steam operation. The locomotives are now overloaded frequently, and have to contend with flue dust, which settles on rheostat and contactor insulation and encourages leakage and short-circuit. Passenger locomotives are inspected electrically and mechanically every 14 days, which period might be increased to 80 days. A passenger locomotive, which was out for 8 years, was overhauled completely in 4½ hours. Freight trains are inspected electrically every 40 days, and not more than one hour is required by one electrician and helper: these engines are often in practically continuous service with only ½ hour for cooling between changes of crew. The overhauling period is determined by the tyre renewals, say, 45,000–47,000 miles.

The original grade F pinions give 90,000 to 115,000 miles' wear; at least 4 times this mileage is expected from the double-drive gears. Arcing horns in the arc chutes are beginning to need replacement; no controller fingers have been changed; 95 % of the contactor tips have run 4 years, and many are expected to last 2 or 3 years more. Main motor brushes (under a tension of 7 to 7½ lbs.) average 18,000 miles' life. Compressor brushes just begin to need renewal. No armature trouble of any kind occurred during the first half of 1917. No armature has ever fallen on a pole-piece. A few flash-overs have been caused by rough cross-overs. The dynamotor commutators alone show appreciable wear (due to entrance of metallic dust). No commutator has been re-slotted. The principal cause of road delays is occasional failure of grid resistors due to overload. Hyatt roller bearings for the pantographs outwear 2 or 3 contact tubes, each of which lasts about 50,000 miles. Lightning is common, but the electrolytic arresters prevent any lightning trouble. Mileage costs for Jan. 1917 are as follows, and refer to a particularly heavy month (88,702 miles by all classes of equipment). The maintenance costs include damage from accidents:—

Electrical equipment, including m/c. shop, materials and depreciation	9·400 cents per mile
Locomotive engineers	8·032
Engine-house, electric (including wiping and housing)	1·267
Electrical energy	17·674
Lubrication	0·405
Other supplies	0·576
Total	37·368 cents per mile

[See also Abs. 91 (1914).] R. E. N.

83. *Effect of Anti-friction Bearings on the Haulage of a Coal Mine.* **P. B. Liebermann.** (Am. Inst. Mining Eng., Bull. No. 127. pp. 1051–1062, July, 1917.)—For hauling coal through the mine and on the surface, locomotives are required of which the size and power consumption depend on the resistance to motion offered by the mine cars. This resistance is principally

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caused by gravity and bearing friction. The effect of gravity can be reduced to a minimum by a suitable lay-out of the haulageways; that is, by arranging the grades in favour of the loaded trips, and by fixing the percentage of grade to that value which gives the lowest power consumption for loaded and empty trains. The bearing friction can be easily reduced to a negligible quantity by the installation of a suitable anti-friction bearing that will stand the rough use and abuse of coal-mine service. The author deals with flexible roller bearings in comparison with ordinary plain bearings.

A dynamometer car was used. This car is equipped with recording instruments, and is entirely automatic in its operation. It is coupled between the locomotive and train, and records the following quantities: draw-bar pull in lbs., speed in miles/hr., and a time interval, usually 5 secs.; the paper travel is proportional to the distance covered by the car. Opposite these records the profile of the road is drawn in by hand, so that full particulars regarding train-resistance for any grade or piece of track can be read from the chart at a glance. From the many tests conducted up to the present time, sufficient data have been collected to obtain a definite idea as to train-resistance and its relation to speed. The test data were found to meet the following equations:—

$R_p = 26 + 0{\cdot}45S$ = train-resistance of loaded plain-bearing cars in lbs. per ton.
$R_r = 9 + 0{\cdot}45S$ = train-resistance of loaded flexible roller-bearing cars in lbs. per ton.

These formulæ apply to average mine conditions, with clean tracks, with cars of from 2 to 4 tons' capacity, and with wheels not below 16 in. in diam. Tests made with empty cars showed that the train-resistance per ton is about 40 % higher for plain-bearing cars and about 15 % higher for the roller-bearing cars than would be obtained from the formula for loaded cars.

The effect of grade on the train-resistance and on the resistance of the locomotive itself is then considered, and equations are given for finding the theoretical grade that will result in equalised locomotive effort in pulling a loaded train down grade and bringing the same train of empty cars up the grade.

Substituting for the train-resistance the figures found by test for the speed of 6 miles/hr., it is shown by the data given, that a clear saving of 2011.50 per year has been accomplished through the application of flexible roller-bearings. These roller-bearing cars are necessarily more expensive than the ordinary plain-bearing cars. The 164 cars in the example would require an additional investment of about $20 per car, or $3280 based on prices prevailing at the present time. This amount is balanced by the saving in the size of the locomotives. Each one of the 8-ton locomotives costs about $1000 more than one of the 8-ton locomotives, resulting in a saving of about $2000. The 8-ton locomotive would require track rails weighing 30 lbs. per yard, while the 8-ton locomotive could get along with 20-lb. rails. The difference in cost amounts to about $8500 for the example, based on $40 per ton and 5 miles of track. C. E. A.

84. *Tilting Track Rails reduces Car Nosing.* **P. N. Wilson.** (El. Rly. J. 50. p. 729, Oct. 20, 1917.)—On some of its reconstruction work the Connecticut Co. is using an incline tie-plate which has the effect of tilting the rails to conform to the coning of the wheels operating over them. The inclination is 1 in 20, bringing the top of the rail normal to the load. It is believed that flange wear will be reduced, thrust will be minimised and internal stresses in the rails will be reduced, thus producing a more favourable effect on the

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bending movement in the axles and reducing the tendency to overturn the rails. It is found that the cars operate over the track under which the plates are placed with less tendency to nose than they do over the track without the plates. This is, no doubt, due to the fact that the wheels tread over the centre of the head of the rail on a uniform wheel diam., whereas with the rail in the usual position in relation to the car wheel there is a tendency for the car to nose on account of one wheel running close to the gauge line of the rail on its largest diam., the other wheel on the same axle running on its smallest diam. This may readily happen with the usual gauge play between wheel and rail, and an oscillation is set up which causes side-wear on the rail head, flange wear, and nosing. C. E. A.

85. *Equipment of Light-weight Cars.* (El. Rly. J. 50. pp. 531–540, Sept. 22, 1917.)—The equipment described has been designed for safety, lightness, and automatic action, particularly to meet the requirements of one-man safety car operation. Numerous illustrations are given in the original paper. A combination air-brake and door-and-step-operating equipment is controlled by one valve which is interlocked with the electrical control. Simultaneously with an emergency application of the brakes, power is shut off, sand is applied to the rail, the front door is opened, the steps are lowered, and the rear door in single-end cars is unlatched so that it may easily be pushed open. The car cannot be started till the steps are up and the doors closed. A foot valve relieves the driver temporarily of the necessity for keeping his hand on the deadman's handle. The special control valve has six positions covering all service contingencies. A poppet valve actuated by the handle of the brake valve permits the rails to be sanded without the operator having to let go the brake handle. The door and step controller can be changed from right to left hand working by moving one plug; and it can be adjusted once for all to suit the exact size and weight of door.

Radical reduction has been effected in the weight of motors. The old standard 35-h.p., 600-volt motor weighed 2000 lbs. (nearly 58 lbs. per h.p.); the pioneer motors for low-floor cars weighed 50 lbs. per h.p.; and the latest 25-h.p. motors for light cars weigh 885 to 900 lbs., *i.e.* 36 lbs. per h.p. The use of low car floor and 24-in. wheels necessitates a relatively long, small-diameter armature; to save weight better materials are used throughout, the armature speed is increased to 1050 or 1286 r.p.m., ball bearings employed and ventilation improved. The use of ball bearings permits a smaller air-gap than is safe with sleeve bearings, and preserves accurate spacing of the gears. Maintenance costs for balls and bearings are low. The motor is so short that its weight would come principally on one wheel if the gear hub had been placed against the wheel. The machine is therefore placed midway between the wheels; this necessitates a special axle lay-out. The GE-258 motor used on Birney and other cars runs at 1286 r.p.m.; at this speed ventilation is so good that the machine has a continuous rating of 35 amps. at 450–600 volts. The high speed necessitates finer-pitch gearing; the new 4½-pitch gears are expected to equal the life of the 3- and 3½-pitch gearing used with larger motors. The Birney motors make very fast schedules with about 4 tons per motor (2 per car); average acceleration is 2½ miles per hr. per sec. The K68 controllers weigh only 270 lbs. the pair, compared with 410 to 450 lbs. for controllers previously standard; the new controller can be used to handle two 40-h.p., 600-volt motors. A new type of resistance, using grids of smaller section, supported at 3 points and having pressed steel ends occupies 24 in. length and less than 8 in. depth; it is easier to install, better protected than

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the old rheostats and weighs only 65 lbs. (a saving of 135 lbs.). The Brill 78-M truck used in the Birney cars weighs 3300 lbs. complete, and has a wheel-base of 8 ft. This is the lightest single truck ever built. The spring system comprises quarter elliptic and spiral springs of the graduated type, a spring-cushioned side casement, and a spring-brake link connection to take the draught. The journal boxes are bolted directly to the side bars. The absence of pedestals saves weight and also wear on the journal boxes; the latter are usually of ball or roller-bearing type. The 24-in. Davis manganese-rim wheel weighs 186 lbs. and carries 25 tons static load without perceptible deflection or permanent set.

Trial is being made of a 35-passenger car (28 ft. overall, 12 ft. wheel-base) with one motor geared to each wheel. The weight of 4 motors and a 2-axle truck is 4000 lbs., and of rest of the equipment 4700 lbs. R. E. N.

86. *Refitting Steel Wheels with New Tyres.* (Canad. Elect. News, 26. p. 35, Sept. 1, 1917. **W. G. Murrin.** El. Rly. J. 50. pp. 823–824, Nov. 3, 1917.)—The British Columbia Electric Railway Co. some years ago inaugurated the practice of refitting their wheels with tyres on both their city and interurban lines. The practice has met with success, and, in consequence, the illustrations in the original article, which indicate in detail this company's practice, are of considerable interest [but are on too small a scale for satisfactory reproduction here]. The standards are shown for both city and suburban wheels. On new equipments the company place a rolled steel wheel having dimensions suitable for use, after they have run their mileage, as centres for tyres. On their city equipment these tyres are shrunk on with no other fastenings than a guiding flange on the front of the face, and the tyre riveted over the edge of the wheel-centre at the back. So far the company have experienced no difficulty with these tyres after wearing to a thickness of 1⅛ in. On their interurban equipment they start with a 33-in. wheel with a 3-in. rim, which, when worn to witness mark, is turned for a centre to which the tyre is bolted in the same way as is used by the Midvale Steel Co., and which is rapidly becoming standard. These rolled steel centres are lighter than cast-iron centres, the combined weight of centre and tyre being very little more than an original wheel. C. E. A.

ELECTRIC LAMPS AND LIGHTING.

87. *The Flickering of Metal Filament Lamps.* **K. Simons.** (Elekt. Zeits. 38. pp. 453–455, Sept. 13; 465–467, Sept. 20, and pp. 474–476, Sept. 27, 1917.)—The article is concerned with the flickering of the light of metal filament lamps and the ranges of frequency and voltage over which the flickering is perceptible. The investigations were instigated by troubles that arose in lighting systems supplied from sets driven by Diesel engines. The paper deals with the determination of the lowest frequency for which the flickering is negligible and the greatest variation of voltage that is permissible. Methods are described for measuring the frequency of the flickering of a source of light. This frequency is related to the variations in the speed of the shaft of the Diesel-driven sets, and this leads to an investigation of the oscillations of the shafts of such sets with two flywheels both by mathematical methods and by experiments on models having sufficiently slow oscillation periods to be followed by the eye. The critical speed at which flickering disappears is found to be proportional to the logarithm of the surface illumination. This fact was determined by illuminating a surface through a rotating screen with a sector cut out. Further tests with alternating currents showed that flicker-

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ing is partly caused by mechanical vibrations of the filaments of the lamps. If the frequency of the supply is not low enough to cause flickering, the trouble may be caused by voltage variations, and a calculation shows that mechanical oscillations of the generators give rise to two oscillations superposed on the fundamental oscillation. This condition was reproduced by superposing an alternating current on a direct current and by inserting in circuit with the lamp a variable resistance that could be made to vary periodically by a motor-driven mechanical attachment to its regulating arm. Tests made on a 82-c.p. metal filament lamp for 220 volts showed that the perceptibility of the flickering was independent of the nature of the current upon which the variations were superposed, *i.e.* was the same with direct as with alternating current, and also that the voltage variation that caused flickering depended greatly on the frequency of the variation. The smallest voltage variation was permissible at 6 cycles per sec., for which frequency flickering was noticeable for a variation of 1 volt; higher voltages were required above and below this frequency, and above about 60 cycles per sec. even large variations did not cause appreciable flickering. The article concludes with a detailed description of methods for determining the frequency of flickering of a lamp and the investigations already referred to concerning the oscillations of shafts driven by Diesel engines. A. J. M.

88. *The Axle-Generator Belt Problem.* **J. R. Sloan, J. R. Davis.** (Rly. Elect. Engin. 8. June, 1917. Am. Soc. Mech. Eng., J. 39. pp. 789–740, Aug., 1917. Abstract.)—Factors affecting belt life in axle-generator service are: Lost motion in running gear of cars; type of generator suspension; track and water conditions; size and alignment of pulleys; belt fasteners and their application; character of belt. Pulley size is an important factor; the smaller the pulley, the greater the belt tension for given power transmission, and the greater the belt wear by internal friction. Most belt fasteners weaken the belt by cutting the fibres, and also introduce a rigid section in the belt. Wide experience on the Pennsylvania Railroad shows that a 5-in., 5-ply belt gives service at minimum cost per 1000 miles. Low belt mileage is due rather to the above-named factors than to poor belt quality; the fastener is the chief factor and rough handling of cars comes next. Sloan suggests that a suitable belt for axle-generator service is a 5-in., 5-ply belt, the yarn being Sea Isle long fibre cotton woven to weigh at least 28 oz. per sq. yd., and with the edges straight, the variation in width not to exceed $\pm 3{\cdot}5$ %. Each inch width of each ply should have a tensile strength of 200 lbs. and the plies should be cemented together with a friction of at least 18 lbs. per in. width when tested at a speed of 20 in. per min. The outer surface should be covered with $\frac{1}{32}$ in. of good rubber. The complete belt under test load should not stretch more than $1\frac{1}{2}$ in. in 18 in.

Davis finds that alignment and maintenance of suspensions and trucks is a more vital factor in belt life than the difference between two types of suspension. Belting and fasteners which are satisfactory with truck-mounted generators may not be suitable for body-mounted generators; the latter require a belt of special quality. Longest belt life is obtained with truck-mounted generators of either 2-point swinging type or parallel type with open-end truck and inside-hung brake beam. The advantages of the body-supported generator include: Easier inspection and repair, especially in bad weather; and reduced maintenance cost of suspensions and troubles relating thereto. These advantages generally outweigh any difference in belt-life performance. R. E. N.

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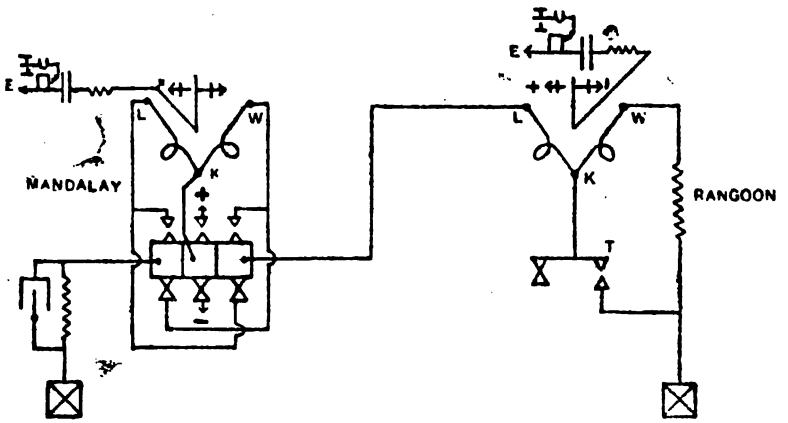
TELEGRAPHY AND TELEPHONY.

89. *A Long-distance Duplex Working Central Battery System.* **R. L. Milburn.** (El. Rev. 81. p. 461, Nov. 16, 1917.)—The method will be understood from the Fig. Work has been successfully carried on between Rangoon and Mandalay, a distance of 386 miles.



The apparatus in the station on the right in the Fig. consists of a key, Vyle sounder, and rheostat without any condensers: on the left it comprises a double-current key with 9 terminals—3 top, 3 bottom, and 3 movable—a polarised G.P.O. 200-ohm relay, a rheostat with condensers up to 80 mfd., sounder, and local battery. E. O. W.

90. *The Lieben Tube.* **R. Lindemann** and **E. Hupka.** (Jahrb. d. Drahtl. Telc. 12. pp. 218–241, Oct., 1917.)—A general theory of the discharge in a Lieben tube is developed, based on the usual ionisation hypothesis. This theory accounts for the effects obtained in the tube both for direct and alternating currents, especially the effects for heavy currents. Experiments are described with steady current, alternating current of frequency 50, and with high-frequency oscillations, which all support the theory advanced. Many interesting oscillograms are reproduced, showing the variations in grid and plate currents. A. W.

91. *The Castelli Telephonophor.* **R. Regnoni.** (Elettricitá, Milan, No. 1843. pp. 137–139, Nov. 1; No. 1844. pp. 145–147, Nov. 8, and No. 1845. pp. 153–155, Nov. 15, 1917.)—On the Italian railways the term "telephonophor" is applied to a telephonic apparatus which utilises as conductors a telegraphic line and the earth. The author recalls the Van Rysselberghe, Perego, and Bruné-Turchi systems for telephoning over a telegraph line and comes to the conclusion that their efficiency depends upon the energy employed in telephoning and that the "separators" of said systems have little effect, if any. Starting from this idea, Castelli has devised his "telephonophor," which essentially consists of a telephonic apparatus the elements of which are so arranged as to obtain relatively strong telephonic currents capable of drowning the sound of telegraph signals. Two types of this apparatus were constructed; a small one for distances of some dozens of km. of iron wire, and a large one for greater distances. The calls are obtained for the large type with a buzzer at the sending station, which energises at the receiving station a relay and a bell; for the small type no

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special call apparatus is used, the loudness of the voice being sufficient for calling. The large type of apparatus was experimented with between Rome and Naples, 250 km. apart, using a 8-mm. bronze wire, and between Rome and Avezzano, 106 km. apart, using 100 km. of 4-mm. iron wire and 6 km. of tunnel cable possessing a capacity of about 0·3 m. per km. The experiments gave satisfactory results. By using condensers and choke coils it is possible to connect several independent telegraph lines. The small pattern allows of several posts being connected ; special switches render it possible to make any one of the posts act as intermediate or as terminal, so that the constitution of the telephonic circuits remain quite independent of the telegraph lines.

Details of construction and diagrams of connections are given in the article. E. B.

92. *Underground Telephone Cables.* G. Viard. (Annales des Postes, Télég. et Téléphones,. 5. pp. 269–281, Sept., 1916. Electrician, 80. pp. 17–18, Oct. 5, 1917. Abstract.)—A consideration of the methods of extending the range of transmission over underground cables by loading, either continuously or with coils, and a comparison of the practice of different administrations. In Great Britain the rule for the spacing of coils is $CL_1l < 25$, C being capacity per mile in mfd., l the distance between two coils in miles, L_1 the self-induction per coil in millihenrys. In America the rule is that the wave-front must encounter at least 7000 coils per sec. In Germany the natural frequency of the circuit formed by the coil and the capacities of the two half-sections of the line on either side is required to be at least 16,000. The following table illustrates the differences between the practice of the three countries :—

Country.	Max. Values of CL_1l.	Minimum Number of Co ils encountered by Wave-front in 1 sec.	Natural Frequency of Element of Line.	Relative Number of Coils Used.
England	25·0	6325	12,650	79·0
America	20·4	7000	14,000	87·5
Germany	15·6	8000	16,000	100·0

In France it has been decided for future construction to follow the rule used in Britain. The following table shows the application of the rule for different degrees of loading :—

Nature of Loading.	Inductance of Coils in Henrys.	Distance between Coils in km.	Inductance added per km.	Values of CL_1l.	Characteristic.
Very weak.....	0·060	9·0	0·007	21·6	410
Weak	0·135	4·0	0·034	21·6	920
Average.....	0·175	8·0	0·058	21·0	1200
Strong	0·250	2·15	0·116	21·5	1700

The qualities desirable in coils, other than a low ratio of effective resistance to self-induction are (1) high insulation, (2) low mutual induction between adjacent coils, (3) small bulk, (4) feeble magnetic remanence. All these points deserve attention, conjointly with cost.

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Disadvantages of heavy loading are that (1) higher voltages must be applied to the line, (2) there is greater liability to cross talk, (3) disturbances produce a more marked effect.

The paper concludes with a discussion of the general advantages of underground circuits over overhead lines. W. H. G.

93. *Relation of Diaphragm Thickness to Characteristics of Telephone Receiver.* (Frank. Inst., J. 184. pp. 723–726, Nov., 1917.)—An account of tests made by obtaining the motional-impedance circles [Abs. No. 490 (1917)] for a receiver fitted with japanned and unjapanned diaphragms of thickness varying from 0·14 mm. to 0·325 mm. in five steps. The bowing of the thin diaphragms towards the magnet poles prevents the proportional increase of natural frequency with diaphragm thickness. The sensitiveness deduced from the diameter of the motional-impedance circle is a maximum for about 0·28 mm. thickness. The optimum thickness depends, of course, upon the mechanical and electromagnetic values of the particular instrument. The resonant range diminished as the thickness increased. W. H. G.

94. *Design of the Telephone Transformer.* **J. B. Pomey.** (Rev. Gen. d'El. 2. pp. 683–687, Nov. 3, 1917.)—H. Pleijel has given [Abs. 805 (1910)] a method of calculating the optimum constants for the windings of a transformer for use between two circuits of known characteristics. This method is more general and neater than that of Breisig. In Pleijel's paper, however, the derivation of the formulæ is abbreviated. The object of the present author is to supply the detail and justify the mathematical transformations used. The article does not permit of a detailed abstract. W. H. G.

95. *Efficiency and Performance of Telephone Lines.* **L. Schultheiss.** (Archiv f. Elektrot. 6. pp. 73–99, 1917.)—The author considers the problem of the comparison of the transmission qualities of different circuits from the standpoint of the power-efficiency of the transmission. The power-efficiency varies with the impedance of the load at the receiving end. Two cases are specially considered: (*a*) when the load impedance is that which makes the efficiency a maximum, $\eta_{max.}$; (*b*) η_s, when the load impedance is equal to the characteristic of the line but reversed in phase. From the efficiency an equivalent attenuation length ($\beta l'$) is derived. The use of this quantity is claimed to have the following advantages: (i) The circuits can be compared for any value of the load impedance; (ii) the comparison can be extended to compound circuits; (iii) the efficiency is very easily measured.

For aerial lines and loaded cables $\eta_{max.}$ and η_s are nearly equal and correspond to the normal βl. For ordinary cables, however, βl only indicates a mean value of the transmission quality, which may be exceeded or the reverse according to the value of the load impedance. The attenuation length is an unfavourable criterion for ordinary cable, since by properly choosing the load impedance the efficiency can be raised considerably above the value corresponding to βl.

An account of the theoretical and practical investigation of different circuits from this standpoint follows, regard being had to the power input into the circuit. This is determined from the e.m.f. and resistance of the microphone, and the method of measuring, and variations in, these quantities are described. Details are given of the examination of central and local battery connections with homogeneous and compound lines, and also of a complete long-distance connection with aerial trunk and cable local lines. The effect of loading the latter is examined; it is stated that in general, loading is only useful when the length exceeds 4 km. W. H. G.

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SCIENCE ABSTRACTS.

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FEBRUARY 1918.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

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PRIME MOVERS.

STEAM PLANT.

96. *Capitalised Value of One-tenth of an Inch of Vacuum.* **C. H. Baker.** (Power, 46. pp. 762–768, Dec. 4, 1917.)—Gives a combination of three charts which shows: (*a*) Saving in dollars per 1000 kw. per annum for various differences in vacuum. (*b*) Capitalised values of (*a*) for various fixed charges. Other charts show the water-rate improvement in a turbine due to 0·1 in. increase in vacuum, and the cost of 1000 lbs. of steam, using coal of various calorific values, various combined boiler and furnace efficiencies, and different prices of coal. Examples are worked out to show the method of using the charts. W. N. Y. K.

97. *Steam-carrying Capacity of Pipes.* **W. H. Thies.** (Power, 46. pp. 824–826, Dec. 18, 1917.)—Gives four charts designed to furnish at one reading the lbs. of steam or rated h.p. that a pipe of given size will supply under given conditions of pressure and velocity. The range includes pipes from about 2½ in. diam. to 16 in. at gauge pressures from 50 to 250 lbs. per sq. in., velocity 6000 or 10,000 ft. per sec., for steam either saturated or superheated 100 deg. F., at the rate of 84·5 lbs. of water per h.p.-hour. [See Abs. 73 (1917).] W. N. Y. K.

98. *The Large Turbo-generator.* **R. H. Rice.** (Gen. El. Rev. 20. pp. 800–809, Oct., and pp. 868–880, Nov., 1917. Abstract of paper read before the Am. Iron and Steel Inst., New York, May, 1917.)—Traces the development in power and efficiency of steam turbines in America from the installation of a 5000-kw. vertical machine by the Commonwealth Edison Co. at Chicago in 1903 up to the 45,000-kw. units of to-day. Curves show (1) the ratio of steam consumption, (2) the relative price per kw., and (3) the variation in weight per kw. of large steam turbines during the period under review. The highest pressure suitable for use is discussed; the maximum at present in use is 300 lbs. per sq. in., with a temperature between 600° F. and 700° F. Recent boilers in central stations show efficiencies of 82 % to 84 %, as against 65 % to 70 % formerly, owing to improvements in stokers, furnaces, large capacity, and economisers. With blast-furnace gas and the best modern equipment it is likely that 81 % efficiency can be obtained. The extensive gas-engine

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installations in steel mills were put in when the steam turbine was much less efficient than now. Three plants for steel mills have been selected as being typical, and are compared for costs. One plant is driven entirely by gas engines, another by steam turbines, and the third by gas engines with such steam plant as is needed for reasonable continuity of working. There are four blast furnaces, each capable of producing 550 tons of pig per 24 hours, consuming 1800 lbs. of coke per ton of iron. In the steam station there are three 12,000-kw. sets, in the gas station twelve 2500-kw.sets, and the combined station includes a gas-electric and a gas-blowing station, and an electric pumping station, with steam spares in all cases. The costs are tabulated :—

First Costs.	All Gas.	Gas Engines with Steam Reserve.	Steam Turbine.
	$	$	$
Secondary washers and pipes	120,660	120,660	—
Electric station	2,094 450	2,164,450	709,640
Blowing station.....	1,001,350	1,085,350	536,304
Pumping plant	246 000	246,000	121 496
Boiler plant	80,000	104,000	656,240
Gas producers	100,000		—
Gas-producer auxiliaries	40,000		—
Total first cost	8,682,460	8,720,960	2,023,680
Running Charges per Year—			
Secondary washers	11,300	11,300	—
Electric station	72,000	72 000	—
Blowing station.....	84 000	84.000	21,920
Pumping plant	5.000	5,000	2,400
Boiler plant	5,000	6,000	54,190
Gas producers	10 000	—	—
Running charges, total.....	137,300	128,300	124,906
Coal, $2 per ton, $0·05 firing	22,000	48.600	60.400
Fixed charges, 18 %.....	472,220	488.725	263 078
Total charges, per year	681,520	660,625	448,384

Other tables give details of power distribution, heat balance for the complete steam-turbine plant, etc. In the *discussion*, **D. S. Jacobus** agreed that 81 % efficiency could be obtained with the most modern boiler equipment, and laid down the conditions for obtaining the best results. **A. Dow** gave particulars of large turbines of the Detroit Edison Co. He had a boiler-house efficiency of 76 % year after year, including losses due to banked fires, without economisers. Conditions of economy in power-house design, in order of importance, are : (1) Furnace and gas passages of the boiler should be adapted specially to the fuel to be used. (2) Condensing system should use to the utmost the high expansion of the steam, without overcooling the condensate. (3) Steam turbine should be reliable. (4) The heat-transfer should be as nearly as possible a closed cycle.

Three tables show working costs of the Connor's Creek power house during 1915 and 1916. [See Abs. 853 (1917).] W. N. Y. K.

99. *A Commercial Analysis of the Small Turbine Situation.* **W. J. A. London.** (Am. Soc. Mech. Eng., J. 39. pp. 981–986, Dec., 1917.)—During the last six years a marked tendency to standardisation has become evident and the types of small turbine now to be considered are (1) the Terry,

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(2) Westinghouse, (3) Curtis, and (4) Kerr. The first three groups employ velocity staging and are single-stage mostly in the small sizes; the Kerr turbine based on pressure staging must be taken separately as a multi-stage machine. Non-condensing turbines are principally considered in three aspects, namely: (1) the type giving the necessary competitive efficiency with lowest maker's cost and reliability in service; (2) the relation between first cost and efficiency in working; and (3) the policy of separate makers of different parts, *e.g.* turbine and pump, towards one another and towards the purchaser. The design varies from that of a large machine because high thermal efficiency is often not required, the heat in the exhaust steam being largely recovered in heaters. Another point is that small turbines, as auxiliaries, are often placed in dirty situations. Success or failure is largely determined by the mechanical design of parts such as bearings, glands, governor, etc. Methods of overcoming the difficulty of shaft alignment are described. Variation in power due to varying pressure is discussed; an example is cited, viz.—

	Steam Pressure.	Quality.	Back Pressure	H.P. Output.
Specified conditions	150	100%	0	100
Operating conditions	140	98%	2	88

Reference is made to a Code of Practice given in an Appendix. Notes are made on the policy of makers, contractors, and subcontractors in case of troubles arising after the plant has been put into service. [See Abs. 507 (1909).] W. N. Y. K.

100. *Maximum Efficiency in Burning Fuel Oil.* **F. W. Small.** (El. World, 70. pp. 1197, Dec. 22, 1917.)—Describes some innovations to obtain economy through a wide working range in a large oil-burning installation on the Pacific Coast. The load on the boilers varies from 33 % to 180 % of rating. At first the steam used for atomisation was about 5 % of the total generated instead of about 1 %. To avoid this excess a steel disc with a $\frac{5}{16}$ in. or $\frac{7}{8}$ in. hole (according to size of boiler) was fitted in the steam supply pipe, to give about 1 % of the steam at normal rating. The extra steam required for overload is supplied through a by-pass with a separate valve. Air admission is regulated in small increments by a damper rod extending to the front of the boiler. The ashpit has adjustable swinging doors. The checkerwork under each burner conforms to the shape of the flame, and the free area of the openings never exceeds 3 sq. in. per rated boiler h.p. The best height for the burner was found to be $4\frac{1}{2}$ in. to $6\frac{1}{2}$ in. above the checkerwork. [See Abs. 543 and 544 (1917).] W. N. Y. K.

101. *Use of Electricity in Connection with Fuel Saving in the Iron and Steel Trades.* **A. H. W. Marshall.** (Inst. El. Eng., J. 56. pp. 28–29, Dec., 1917. Chairman's Address to Newcastle Section. Electrician, 80. pp. 550–551, Jan. 11, 1918. Abstract.)—The greatest development of electricity will take place in association with these trades after the war. The idea that there are enormous quantities of gas and waste heat available for conversion into electrical energy for use outside the works is a mistaken one, arising because the several processes concerned have been considered separately, *i.e.* smelting, coke-making, steel-making, and rolling. In a properly co-

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ordinated undertaking spare power is only available by taking advantage of every means of heat recovery, except at such times as when the steel-works end of the plant is shut down. Table I shows the estimated heat available at each stage in terms of one ton of coal carbonised.

TABLE I.

DISTRIBUTION OF ENERGY IN 1 TON OF COAL (12,500 B.TH.U.) CONTAINING 8200 KW.-HRS.

Quantity of Product.	Carbonising 1 Ton of Coal.	Kw.-hrs.	Kw.-hrs. available for Conversion into Power.
5500 cub. ft.	Gas used on ovens	690	—
5000 cub. ft.	Gas surplus	680	—
0·7 ton	Coke	6000	—
0·05 ton	Coke breeze	300	—
100 lbs.	Tar	470	350
2·5 galls.	Benzol	110	—
		8200	
	Smelting 0·64 Ton of Pig Iron.		
81,700 cub. ft.	Gas used on stoves	980	—
73,800 cub. ft.	Gas surplus	2160	—
1 ton	Slag (sensible heat)	650	650
0·64 ton	Pig iron	250	—
	Furnace reaction and loss	2010	—
		6000	

UTILISATION OF SURPLUS GAS FROM COKE OVENS AND BLAST-FURNACES.

Making steel (0·68 ton)	1200	800
Reheating ingots (0·68 ton)	890	—
Balance	1200	1200
	2790	2500

CONVERSION TO ELECTRICAL OR MECHANICAL POWER.

Total available energy	2500
Less slag value	650
	1850

Thermal efficiency . . . . . 15 %

1850 × 0·15 = 280 kw.-hrs. per ton of coal.

About one-half of the coke-oven gas is available for outside use; its calorific value (net) is 480 B.Th.U. with benzol extraction of 2½ galls. per ton. It is not so suitable as producer or blast-furnace gas for engines, on account of sulphur content and pre-ignition troubles, but for boilers it has high efficiency and gives greater output than coal for the same heating surface. Blast-furnace working conditions are dealt with. The usual criterion of economy in coke is the ratio of CO to CO_2 in the gas, this being usually a little under 8 to 1. The efficiency of the blast air heating furnaces is generally poor—50 % only—but can be improved to nearly 70 % by cleaning the gas. The heating of basic open-hearth furnaces and mixer is usually

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done by a gas producer consuming 6 cwt. of coal per ton of steel ingots. The gas given off has a value of 180 B.Th.U. Coke-oven or blast-furnace gas can be used, and these give a more uniform supply than the producer. The first available source of energy is the tar from the coke-oven gas in the by-product plant. The use of heat from slag for heating water, and experiments in applying the steam so raised in low-pressure turbine plant are considered. The cleaning of blast-furnace gas involves expense and about 2 % loss of its power value, but it is essential for high efficiency. About 50 lbs. of dust comes away with the gas per ton of pig iron. Dry and wet cleaning methods are compared and scope for general improvement in fuel economy is indicated. With a complete system of heat recovery the annual saving of coal in the country would be about 5,500,000 tons. Electricity for haulage has not received sufficient attention, while steam consumption in locomotives is very high. The total electrical energy to be dealt with on an estimated output of 14,000,000 tons of steel next year works out at 8800 million units, with a max. load over 600,000 kw. W. N. Y. K.

102. *Cooling Water for Power Plants.* **C. C. Thomas.** (Am. Soc. Mech. Eng., J. 39. pp. 977–980, Dec., 1917. El. Rev. and West. Electn. 71. pp. 1111–1113, Dec. 29, 1917.)—Describes the methods used to asoertain the conditions governing the cooling of water by means of spray ponds. The experiments were made at the Johns Hopkins University with a new spraying device, the Thomas adjustable spray head. The pond is of concrete, 85 ft. in diam. × 4 ft. deep. The steam plant is a 50-kw. Buckeyemobile with a surface condenser. The spray head tested consists of a cast-iron base, containing the water entry, carrying a 8¼-in. outside diam. vertical bronze tube in which is cut a spiral opening of coarse pitch. The opening slopes up at an angle of about 60° from the axis of the tube so that the water is thrown upward at this angle. The tube is held by a central bronze stem passing through a cap and the base, adjustable by a bell-crank lever so that the width of the spiral opening can be varied, and the thickness of the water film can be controlled. Test results are tabulated.

Test No.	1	2	3	4	5	6	7	8
Date, 1917	9-27	9-28	9-29	10-3	10-4	10-5	10-6	10-8
Duration of test, hours	6½	6½	4½	8	8	8	6	8
Hook-gauge, zero, ft.	1·422	1·422	1·422	1·422	1·422	1·422	1·411	1·411
" " 1st read ng	1·593	1·593	1·592	1·577	1·571	1·597	1·598	1·511
" " last reading	1·565	1·570	1·582	1·571	1·552	1·584	1·545	1·481
" " loss	0·028	0·022	0·010	0·006	0·019	0 013	0·053	0 030
Pressure at nozzle (inches Hg)	4·27	6·10	3 00	5 24	6·74	6·23	6·59	5·10
Temperature, inlet °F.	86·0	83·5	84·0	73·9	79·6	81 6	70·3	80·0
" from pond	80·4	77·8	78·0	70 6	73·6	74·3	64·6	70·2
Cooling range	5 6	5·7	6·0	3·3	6·0	7·3	5·7	9·8
Temperature, Dry-bulb	75·8	75·7	76·0	69·6	75·2	73·1	59·4	63 5
" Wet-bulb	66·6	68·2	66·0	57·1	62·0	61·9	50·1	56·5
Depression, deg. F.	9·2	75	10·0	12·5	13·2	11·2	9 3	7·0
Humidity, %	6·2	70	6·0	46	47	53	53	65
Water loss, % per hour	2·49	1·99	1·30	0·488	1·59	0·934	4·99	4·11

The efficiency of cooling ponds and towers is discussed and curves are drawn from the results obtained by experiment showing variation of efficiency with water pressure, capacity of spray head, etc. Better efficiencies were found when the water fell upon the bare cement bottom of the pond than when the normal quantity of water was present. It is hoped to make further tests to check this observation. The capacity of each spray head is from 150 to 250 galls. per min., and each one will deal with the requirements of a 50- to 75-kw. plant. [See Abs. 168, 886 (1915).] W. N. Y. K.

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GAS, OIL, AND WATER ENGINES.

103. *Oil-engine Exhaust Heating.* (Power, 46. pp. 823–824, Dec. 18, 1917.)—The American Chocolate Almond Co., Jersey City, uses the exhaust gases from a 60-h.p. oil engine to heat the water for warming the factory. The gases are passed through a vertical cast-iron economiser of ten round sections arranged so that their exhaust passages are staggered. The water space surrounds the gas passages and the flow is counter-current. A tapered length of pipe connects the 6-in. exhaust to a 10-in. inlet on the economiser; the engine-jacket water enters the economiser by a 1¼-in. pipe at the bottom andoverflows at the top. The temperature is increased from about 150° F. to 250° F. When the engine is underloaded the extra heat required for warming the building is added in a live-steam heater supplied from a small boiler at 10 to 15 lbs. pressure, with automatic control by a thermostatic valve. W. N. Y. K.

104. *Escape of Exhaust Gas in Two-stroke Engines.* G. B. Petter. (Engineering, 105. p. 1, Jan. 4, 1918.)—Two-stroke engines have inlet and exhaust ports in the cylinder walls, uncovered by the piston towards the end of the outward stroke. The exhaust ports are given a lead so that the exhaust may get away by the time the air ports open. It is required to know the time taken for the exhaust pressure to fall from its initial value to atmospheric.

The velocity of exhaust escape is affected by many factors, especially the contraction of the gas by cooling. For purposes of comparison it is assumed that the fall of pressure is due wholly to escape of gas through the exhaust ports at constant velocity. Let v = constant velocity, in./sec.; p = abs. pressure in lbs. per sq. in., at t secs. after exhaust opening; V = cub. in. of cylinder and cylinder head capacity above piston when exhaust ports begin to open; A = exhaust port area (sq. in.) open at instant t; b = total width of exhaust parts, in inches; m = engine speed in degrees per sec.; a = crank throw; c = connecting-rod length, in.; e = line from crankshaft centre to gudgeon pin, in inches. Suffix o denotes initial conditions when exhaust ports begin to open; suffix f, final conditions when atmospheric pressure is reached; p_f = atmospheric pressure (abs.) It is shown in the original that:—

$$V = \frac{vA_f(p_0 + 2p_f)}{6(p_0 - p_f)} = vabt_f \frac{p_0 + 2p_f}{6(p_0 - p_f)} \left\{\cos(D_0' - mt_f) - \cos D_0\right\},$$

where D_0 = crank angle (before dead centre) at moment of exhaust port opening. This formula assumes that the fall of pressure is directly proportional to time, and neglects obliquity of connecting rod. From it, v may be calculated if t_f is known; or t_f if v is known. The results will not be physically correct, but serve for the purposes of comparison. Taking t_f from the indicator card the formula gives a mean value for v under ordinary working conditions. For the Petter crude oil engine v = 1650 ft./sec.

Using this value of v, the formula gives suitable values for the width and lead of exhaust ports. R. E. N

105. *Determination of the most Economic Dimensions for the Principal Elements of an Hydraulic Power Installation.* E. Baticle. (Comptes Rendus, 165. pp. 995–997, Dec. 17, 1917.)—Let N_iQ_i be the initial power and corresponding delivery; N_m, Q_m the average power and delivery; Q_m^2 the average of the squares of the deliveries; H the total gross fall; h_i and h_m the max. and average loss of charge in the lateral pipe; h'_i and h'_m the max. and

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average loss of charge in the pressure pipe ; d the diam. of the lateral pipe in the case of a circular pipe at full delivery, or the diam. of such a circular pipe as at full delivery will render the same delivery and loss of charge as the lateral pipe ; d' the diam. of the pressure pipe ; l and l' the lengths of the lateral and pressure pipes. The annual cost of the installation will be given, to a sufficient approximation, by the expression :

$$P = a + \beta l d + \beta' l' d' + \gamma 10 H Q,$$

the coefficients a, β, β', γ, being determined in the paper. The most economic values for d, d', and Q_t are those which give the minimum cost of the annual horse-power P/N_m. Therefore—

$$\partial/\partial h_m \,.\, P/N_m = 0 \text{ (or } \partial/\partial h_t \,.\, P/N_m = 0) ; \; \partial/\partial h_m \,.\, PN_m = 0 \text{ and } \partial/\partial Q_t \,.\, P/N_m = 0.$$

The fundamental equation which determines the most favourable delivery for the installation is then found to be : $a + \gamma \,.\, 10 H Q_t = \gamma 10 H Q_m \,.\, 865/n$, where n is the number of working days. Also $P/N_m = (d + \gamma \,.\, 10 H Q_t)/[10 Q_m (H - 6_s)]$, where z is the loss of charge.

This fundamental equation is shown to be absolutely general. H. H. Ho.

106. *Influence of Aspect Ratio on the Critical Angle of Inclined Surfaces.* **C. H. Powell.** (Engineering, 104. p. 677, Dec. 28, 1917.)—For a flat plate

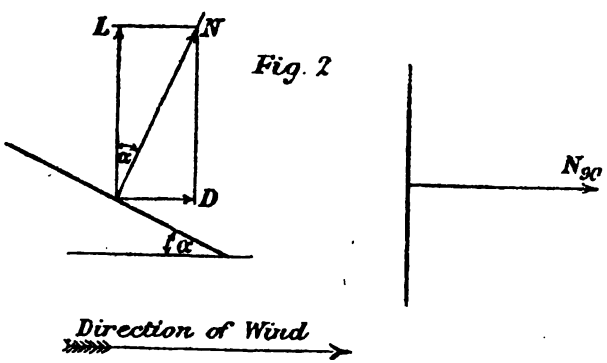

Fig. 2

inclined to a wind, it is known that there is a certain angle of incidence at which the lift, or cross-wind force, is a maximum. This angle is defined as the critical angle. It is known that the critical angle increases as the aspect ratio diminishes according to a definite function. Investigations at the National Physical Laboratory on a long inclined wire, which approaches zero aspect-ratio, show that the normal force is very nearly proportional to $\sin^2 \alpha$, where α is the angle of incidence (see Fig.) that is, $N = N_{90} \sin^2 \alpha$ roughly. In the case where the normal force is coincident with the resultant and varies as $\sin^2 \alpha$, let L represent the lift and N the normal force, then $L = N_{90} \sin^2 \alpha \cos \alpha$. For the max. value of L we have by differentiation $dL/d\alpha = N_{90} (2 \sin \alpha \cos^2 \alpha - \sin^3 \alpha) = 0$, whence $\alpha = 54{\cdot}8$ deg.

The practical importance of a high critical angle from an aeroplane designer's point of view is, that a control surface such as a rudder or elevator of high aspect ratio, will not give any further effect on the aeroplane after about 20°, whereas it is desirable for special manœuvres, that the control surfaces should give a cross-wind force increasing with angle throughout their range of movement, which at present on most machines is not greater than 40°. J. W. T. W.

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PROPERTIES OF ENGINEERING MATERIALS.

107. *Physico-chemical Properties of Chrome-Nickel Steels.* **H. J. French.** (Met. and Chem. Eng. 17. pp. 473–476, Oct. 15, 1917.)—Summaries are given to show the properties that may be developed by the heat treatment of certain chrome-nickel steels.

Results are given of tests on 5 steels varying from 1 to 8 % Ni, and from 0·5 to 1·0 % Cr. The heat treatment consisted of oil-quenching from 1470° F. and reheating to temperatures varying trom 700° to 1800° F.

Photomicrographs are given to show typical structures. C. O. B.

108. *Action of Caustic Liquors on Steel Plates.* (Engineer, 124. p. 496, Dec. 7, 1917. **C. E. Stromeyer.** Engineering, 104. pp. 645–646, Dec. 14, 1917.)—Excerpt from Annual Report to Manchester Steam Users' Assoc.)—Recent experience of the action of caustic soda with evaporator tubes showed that these cracked above and below the tube-plate; at the plate zone, where the expander had produced a compression stress in the tube, there were no cracks, but tube-plates in which there would be tension stresses and also occasional rivets were seriously affected. Experiments were carried out in order to ascertain whether the embrittlement occurs only when the steel is in tension. Tests with rings indicated that when exposed to the action of caustic soda while in a state of tension, they became brittle, and cracked when bent, but those treated in a state of compression showed no signs of cracking.

Other tests are described which were carried out on bars of different classes of steel, but the treatment in autoclaves had removed the spring out of the samples, and the condition of maintaining the samples in a stressed condition had not been fulfilled. These samples showed no loss of ductility, but proved to be very difficult to cut. (**E. Worsley,** *ibid.* p. 657, Dec. 21, 1917.) C. O. B.

109. *Fire and Load Tests of Columns.* (Eng.News-Record, 79. pp. 215–216, Aug. 2, 1917.)—A testing machine has been installed in the Underwriters' Laboratory in Chicago for the purpose of determining the effectiveness of different types of fireproof columns under the combined action of fire and load. The column to be tested is placed in a furnace 7 ft. × 7 ft. × 12 ft., and loaded by means of a hydraulic ram of 256 tons' capacity. Arrangements are made for determining deformation and deflection of the column and also for measuring the furnace temperature. It is also proposed to determine the effect of streams of water on the hot and loaded columns. F. C. A. H. L.

110. *Design of Springs for Oscillating Masses.* **G. Lindner.** (Zeits. Vereines Deutsch. Ing. 61. pp. 907–912, Nov. 10, 1917.)—The author cites various applications in which oscillating masses are fitted with springs to relieve a crank drive of acceleration forces or, in general, to permit a certain latitude of motion in one part whilst relieving others of shock. A number of formulæ are given to facilitate the choice of a suitable type and size of spring for any particular application. One of the primary functions of springs is to relieve the driving members (*e.g.* connecting rod, eccentric and crankshaft bearings, etc.) of "free forces" due to reversal of oscillating masses, which free forces cannot be balanced within the machine itself. The spring should be capable of continuing

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the oscillating motion; in other words, the drive has only to overcome the air-resistance and friction of the moving parts once the oscillation is started. In order to secure the same frequency, the force exerted by the spring at max. deflection must equal the centrifugal force of the oscillating mass at its dead point. The centrifugal force exerted at distance r cm. from the centre by G kg. at n revs. per min. is: $P = G(r/100)(n/80)^2$. The spring is designed so that it is deflected r cm. by the force P, and is not then over-stressed. The present comparison between various types of springs is based on the following assumptions: Spring steel with $E = 2{,}200{,}000$ kg./cm.^{2}; bending stress at deflection r cm. $= 8000$ kg./cm.^{2} unhardened and 4000 to 5000 kg./cm.^{2} hardened; half these values for machine steel. In a numerical example for each case, $G = 50$ kg.; $r = 2$ cm.; $n = 800$ r.p.m.; then the centrifugal force and spring force $P = 100$ kg. The cases considered are: Parallel plate springs with one end fixed and with both ends fixed; triangular plate springs and the practical form of the latter, the trapezium plate; rectangular and round rod springs (including the case of a bundle of rods and that of rods held at both ends); cubic paraboloid (round rod of uniform resistance); and tapered round rod springs. In each case formulæ are given for the relation between length and cross-section of springs, for the volume of and the work done in bending the springs and so forth. The liability to buckling is discussed, and it is shown how to complete practical designs after obtaining the dimensions theoretically desirable. Sections of uniform resistance or approximations thereto are most economical of material. Rod springs of standard profile may be conveniently applied to a variety of load conditions and they are flexible in all directions. Parallel round rod springs require 4 times as much material as triangular plate springs and $\frac{4}{3}$ times as much material as parallel plate springs and rectangular rods owing to the fact that max. stress exists only in the clamped section and along the outer fibre thereof. If the form of the rod be a cubic paraboloid, the material required is only $\frac{1}{3}$ that of a cylindrical round rod and $\frac{2}{3}$ that of a triangular plate spring. The section in which max. stress occurs in a tapered round rod depends on the degree of taper. Up to the critical ratio of taper, $D/d = 1{\cdot}5$, the stress at the clamp determines the design; with more pronounced taper, the danger-section moves towards the point of the spring. The relative economy in material of various patterns of spring is shown by the following formulæ for their volume:—

	Volume =		Volume =
Parallel plate spring	2·2 Pr	Plain taper round rod:—	
Triangular plate spring	0·73 Pr	With $D/d = 1{\cdot}0$	2·935 Pr
Trapezium plate spring; limits	0·73 to 2·2 Pr	$D/d = 1{\cdot}25$	1·91 Pr
Trapezium plate spring; $b/B = 1/5$	0·97 Pr	$D/d = 1{\cdot}5$	1·377 Pr
Rectangular rod spring	2·2 Pr	$D/d = 1{\cdot}84$ (max. economy)	1·18 Pr
Parallel round rod spring	2·935 Pr	$D/d = 2{\cdot}0$	1·20 Pr
Cubic paraboloid	0·978 Pr	$D/d = 2{\cdot}5$	1·45 Pr
		$D/d = 3{\cdot}0$	1·88 Pr

The thickness of a plate spring is limited by the deflection, and its breadth by the force and frequency. In a bundle of spring rods either the number or the length may be chosen freely. Some of the formulæ in the original may be simplified for approximate calculations. R. E. N.

111. *Design of Coil Springs.* **W. F. Brown.** (Automobile Eng. 7. p. 286, Oct., 1917. Am. Soc. Mech. Eng., J. 89. pp. 1043–1044, Dec., 1917.

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Abstract.)—Tables are given of constants which simplify and accelerate the calculation of coiled springs made of round or square wire from 7/0 to 25 S.W.G. Special cases may be calculated from the basic equations. The following symbols are used: D = diam. of wire, inches; Δ = total deflection, inches; W = total load, lbs.; w = lbs. per in. deflection; n = number of free coils; d = diam. of coil pitch circle, inches; c = 12,000,000 lbs. for steel. For round wire $w = cD^4/8nd^3$...(1) and for square wire $w = 8cD^4/60{\cdot}5nd^3$...(2). The total deflection is $\Delta = W/w$. In addition, we require to know the size of wire for a spring to take a certain load. The following formulæ are recommended:—For a safe load of W lbs., $D = \sqrt[3]{(Wd/11{,}750)}$ for round wire and $D = \sqrt[3]{(Wd/13{,}000)}$ for square wire. If the spring may be worked almost to the elastic limit, $D = \sqrt[3]{(Wd/27{,}400)}$ for round wire and $D = \sqrt[3]{(Wd/80{,}000)}$ for square wire. Equations (1), (2) may be written $w = k/nd^3$, where $k = cD^4/8$ for round wire and $k = 8cD^4/60{\cdot}5$ for square wire. Values of k are given for round and square wires from 7/0 to 25 S.W.G. A second table gives cubes and fourth powers of the gauge diameters. R. E. N.

112. *Modulus of Elasticity of Stranded Copper Cables.* **B. Welbourn.** (Inst. El. Eng., J. 56. pp. 53-54, Dec., 1917.)—Describes experiments to determine whether the modulus of elasticity of copper cables varies with the number of strands. Experiments were made on cables of 7, 19, and 37 strands, the method of test being as follows: (1) The cables were stretched between two quite rigid supports with their ends at the same level and with about 6 in. dip (*i.e.* to just under half the breaking stress) and left for two hours to allow the strands to settle down, (2) the span was then let out to approximately 12 in. dip (about one-fifth of the breaking stress) and the dip d_1 at the centre of the span was measured; (3) the span was then loaded with an extra length of the same size of strand, this being bound to the first strand by means of a lapping of string, and the new dip d was measured. On removing the extra length of strand the original strand returned to dip d_1. From these results the modulus was calculated by Still's formula, $W_1/d_1 - W/d = 64(d_1^3 - d^3)MA/8l^4$, where W_1 and W are respectively the weights of unloaded and loaded strand (in lbs.), A is the cross-section of the strand in inches, and l is the length of the span in ft. The results obtained showed that the modulus M decreased from 20×10^6 to $15{\cdot}5 \times 10^6$ lbs. per sq. in. for 7-strand and 37-strand cable respectively. J. W. T. W.

113. *Forced Lubrication.* **Rayleigh.** (Engineering, 104. p. 617, Dec. 14, and p. 697, Dec. 28, 1917.)—The case here dealt with is that of a shaft with a flat end bearing against a flat surface surmounted by a cylindrical cup. The permanence of the layer between the end of the shaft and the flat base of the cup requires a continuous forcible feed. An expression is derived for the work required to maintain the feed through a small hole in the centre of the base, and from this it is seen that a small value for the thickness (h) of the layer of oil between the flat surfaces is advantageous. In practice, the diminution of h calls for great accuracy in fitting together the two opposed surfaces, which, however, need not be accurately plane, and also for the removal of all suspended solid matter from the lubricant. When this is attended to, there should be no wear of the solid surfaces, provided the feed of lubricant is established before the rotation commences. A. W.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

114. *The Electric Furnace in Non-ferrous Metallurgy.* **D. D. Miller.** (Met. and Chem. Eng. 17. pp. 537–541, Nov. 1, 1917. Part of paper read before the Am. Inst. of Metals, Sept., 1917. El. World, 70. pp. 802–805, Oct. 27, 1917.)—It is pointed out that very special types of furnace are required for dealing with non-ferrous alloys, more particularly with those of high zinc content, such alloys being poured at a temperature which is but slightly below their boiling-points. Brief particulars are given of a number of furnaces that are being developed for this class of work, such as the Gillett, the Conley, the Thomson-FitzGerald, the Northrup and the Hering. Brief particulars are also given of the results obtained. W. R. C.

115. *Cost of Electric Pig Iron in Sweden.* (Engineering, 104. pp. 621 and 628, Dec. 14, 1917.)—At present a power of 19,200 kw. is being employed at four works with 6 furnaces for the production of pig iron in Sweden, which corresponds to a production of 65,000–70,000 tons of pig iron and a consumption of 110,000–120,000 tons of iron ore and about 25,000 tons of charcoal per annum. Coke has not been found satisfactory. Ore is used unroasted owing to the low percentage of sulphur, which is neutralised by a certain amount of manganese. The figure of energy required depends on whether the contract kw.-year is taken as a basis, or the full kilowatt-year as measured at the switchboard. The average load factor is about 88 %, the production of pig iron per contract kw.-year being 8·22 tons for a single furnace and increasing up to 8·68 tons where 4 furnaces are employed (which is equivalent to 0·272 contract kw.-year per ton). Calculations by the Jernkontoret are based upon 400 kg. of charcoal, 1600 kg. of iron ore and 0·272 kw.-year per ton of pig iron. The cost of electric smelting plant is about £10 8s. 0d. per kw. The following detailed figures of cost are given for the works at Gellivarc and at Lulea :—

	At Gellivarc. Shillings.	At Lulea. Shillings.
1600 kg. of ore	18·24	21·60
Limestone	0·67	0·44
25 hectolitres of charcoal (400 kg.)	20·83	18·05
0·272 kilowatt-year	14·40	20·34
Electrodes	1·84	1·66
Repairs	3·66	3·33
Wages	6·54	5·44
Management, etc.	2·22	1·94
Royalty (to owner of land)	1·40	1·36
	69·80	74·16
Sinking fund	3·61	3·28
Interest	5·72	5·40
	79·13	82·84

W. R. C.

116. *Recording of Wave-shapes by the Ionising Action of Kathode Rays.* **E. Lübcke.** (Archiv f. Elektrot. 6. pp. 161–164, 1917.)—In a previous article [Abs. 594 (1917)] it has been shown how the wave-shape of high-

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frequency voltages may be measured by a kathode beam produced in a Braun tube. Details are now given of tubes that may be used for extra high frequencies and the limits of the method are discussed. It is necessary to take into account the fact that the kathode-ray moves with a finite velocity; and, allowing for the time for it to travel from the point where the rotating field is applied to the slit and from the slit to the fluorescent screen, it is calculated that the average value of the voltage over intervals of 1/100 sec. may be obtained with sufficient accuracy with waves down to 100 m. wave-length at an applied voltage to the tube of 220 volts, and with waves down to 100 m. wave-length at an applied voltage of 23,000 volts. With an applied voltage of 220 volts the instantaneous values of an alternating voltage of wave-length 100 m. may be determined with an accuracy of about 1·5° and 1·5 volts. A. J. M.

117. *Theorem of Conservation of Reactive Volt-Amperes.* **E. Haudié.** (Rev. Gén. d'Él. 2 pp. 1012–1018, Dec. 29, 1917.) [See Abs. 832 (1917).]—It is shown that this theorem can be easily demonstrated by means of the ordinary vector polygon. Thus, in the case of series circuits if I be the current, U the applied e.m.f. and ϕ the angle of phase-difference for the whole circuit, U_1 U_2, etc., the e.m.f. absorbed in successive circuits, ϕ_1, ϕ_2, etc., the corresponding phase-difference, then $U \sin \phi = U_1 \sin \phi_1 + U_2 \sin \phi_2 + \ldots$, and if this expression be multiplied through by I the theorem is established. The case of parallel circuits can be treated by a similar consideration of the current polygon. (**M. Latour**, *ibid.* 3. p. 278, Feb. 23, 1918.) F. T. C.

118. *Magnetic Flux Distribution in Annular Steel Laminæ.* **A. E. Kennelly** and **P. L. Alger.** (Am. I. E. E., Proc. 36. pp. 999–1017, Dec., 1917.) An investigation of the radial variation of the magnetic flux density when a circular steel lamina is subjected to circumferential m.m.f. from a distributed toroidal winding. A laminated core was built up of 25 annular stampings of high-silicon steel, insulated from one another by layers of paper. Small holes were drilled through the core in a diametral line and perpendicular to its plane, dividing it into three concentric annular belts of approximately the same cross-section. The magnetic flux in each belt could be determined separately by aid of suitable windings through the holes and also oscillograms of the induced alternating voltage wave-forms. Tables of results and curves are given in the paper for primary impressed sinusoidal voltages of frequencies 60, 346, and 696 cycles per sec.

There is a marked variation in the flux density, to be attributed for the most part to variations in the permeability under different values of the magnetising field at the different radii, the lateral magnetic screening being small in comparison. At low flux densities the difference is most marked and at high frequencies the effect is complicated by skin effects. The total flux in the lamina being sinusoidal, the individual belt fluxes are non-sinusoidal. The external belt flux has in general the most distorted wave-form. Defining the flux-density distortion as the difference between the inside and outside flux densities divided by the flux density at the geometric mean radius, then at low densities this quantity is approximately 0·68. The magnitude of the flux-density distortion depends upon the ratio of the width of the lamina to the geometrical mean radius. The smaller this ratio the less the distortion. L. L.

119. *Determining Section of Copper Conductors.* **A. Curchod.** (Rev. Gén. d'Él. 2. pp. 803–805, Nov. 24, 1917.)—The accompanying chart makes possible the rapid determination of the section of copper conductors with

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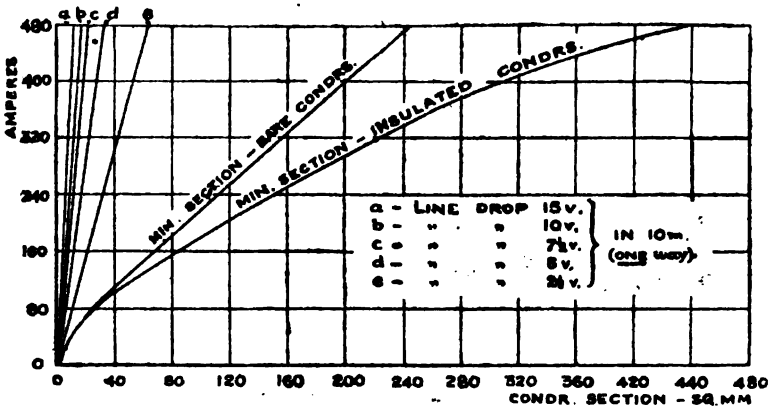
sufficient accuracy for practical purposes, without other preliminary calculation than determining the current density. The conductor section is fixed by reference to the ohmic resistance of the circuit and the heating of the conductor in service. From the resistance standpoint, $s = 0{\cdot}082\, Il/e$; where s = conductor section, mm.², l = length of circuit (one way in metres), I = amperes carried, e = permissible voltage-drop, and resistance of copper = 1·6 microhms per cm.-cube. The section to be provided is affected by the heating due to specified current density, but the heating varies with the conditions of radiation, with the temperature of the surroundings, and with the time for which the conductor is in service. The cooling surface of small conductors is relatively greater than that of large conductors, hence the permissible current density is higher in the smaller conductors. In any case the current density should not be greater than corresponds to a temperature-rise of say 15–20 deg., and the section as determined from the resistance equation must be checked to see that it does not lead to excessive heating.


a b c d e
480
400
320
240
160
80
0
AMPERES
MIN. SECTION - BARE CONDRS.
MIN. SECTION - INSULATED CONDRS.
a - LINE DROP 15 v.
b - " " 10 v.
c - " " 7½ v.
d - " " 5 v.
e - " " 2½ v.
IN 10 m. (ONE WAY)
0 40 80 120 160 200 240 280 320 360 400 440 480
CONDR. SECTION - SQ. MM

The chart contains two curves showing the permissible section corresponding to various current densities in bare and insulated conductors; heating is more rapid for a given current density in insulated conductors.

A second chart in the original is identical with the present one, save that it is to larger scale and for a smaller range of current (0–80 amps.). The five lines at the left of the chart show the section corresponding to various currents for various values of pressure drop in 10 m. of line. The section as determined from the appropriate one of these lines must be multiplied by $l/10$, where l is the one-way length of the line. *Example.*—Required, the section of a 100-m. insulated conductor to carry 800 amps. with a pressure drop of 5 volts. The right-hand curve shows the section required from the heating standpoint to be 202 mm.² The reading on the 5-volt drop line is 21 mm.² which, multiplied by 100/10 gives 210 mm.². This being the larger of the two values is the one accepted; if the heating curve had given the larger section that value would have been adopted.

When selecting conductors for the component parts of a branched circuit it is only necessary to determine the current required in the individual branches, and hence in consecutive portions of the distributing line, after which the chart may be applied to each section of the circuit in turn. The chart is applicable to a.c. circuits if inductance and capacity effects may be neglected, and provided that allowance be made for power-factor if less than

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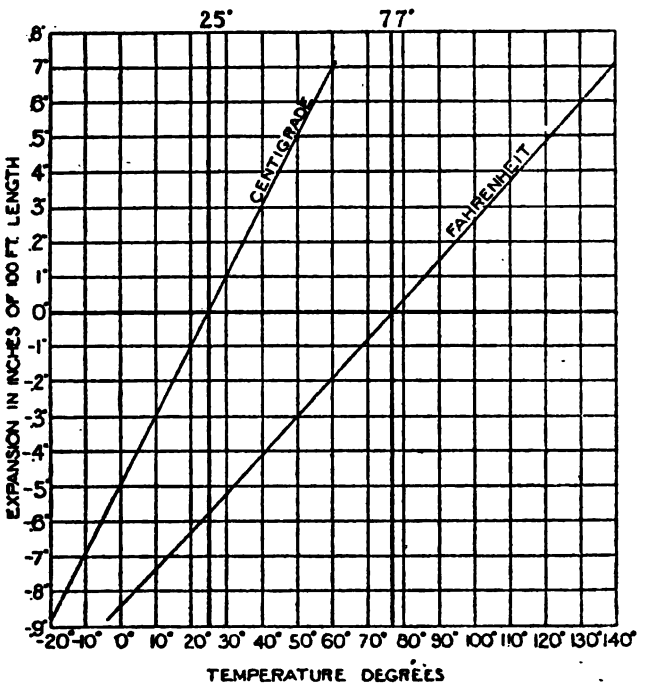
unity. In the case of 8-phase current the section indicated by the voltage-drop curves must be halved ; the minimum section given by the heating curve needs no such correction : the larger value for *s* is taken as before. The section of conductors for small currents is determined by considerations of mechanical strength. The diam. of an insulated wire should not be less than 0·9 mm. and that of a bare conductor not less than 2 mm. The curves given for minimum section (on heating basis) are purely empirical and are drawn from data compiled by the Union des Syndicats de l'Électricité. R. E. N.

120. *Linear Expansion of Copper Bus-bars.* (El. World, 70. p. 957, Nov. 17, 1917.)—Thermal expansion of bus-bars may damage the supporting insulators or destroy the alignment of switches placed in immediate connection with the bus. The Fig. is arranged to show directly the actual change in length of 100 ft. of copper bus-bar over any reasonable temperature-range,



expressed either in deg. C. or deg. F. For simplicity, expansion is taken both ways from an assumed installation temperature of 25° C. (77° F.) ; so that for all ordinary temperature ranges the total expansion is the sum of the values shown above and below the installation length. *Example.*—Suppose that a 100-ft. bus-bar changes from 10° C. to 55° C., it would contract 0·8 in. below installation length at 10° C. and expand 0·6 in. over installation length at 55° C., that is, the total change is 0·9 in.

Damage to insulators or switches may be prevented by the use of expansion joints. The expansion determined by the Fig. is somewhat greater than the expansion of the bar relative to the supporting structure. The latter has generally a lower effective coefficient of expansion, a lower temperature-change than the bus-bar, and a more gradual change, since heat is not developed in the material itself. R. E. N.

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121. *Apparent Dielectric Strength of Varnished Cambric.* **A. E. Kennelly and R. J. Wiseman.** (El. World, 70. pp. 1138–1141, Dec. 15, 1917.)—This paper describes further peculiarities in the behaviour of varnished cambric under dielectric test without entirely explaining the causes. Farmer found [Abs. 280 (1914)] that the apparent dielectric strength of varnished cambric 0·3 mm. thick, between flat metal disc electrodes, decreased more than 50% in changing from very small discs to discs exceeding 15 in. in diameter. The same phenomenon was observed, in varying degree, with films of hard rubber, oil, and air. Part of the diminution in apparent strength is probably due to weak spots in the cambric, but such could hardly occur in air or oil films. When cambric is immersed in oil, there is less decrease in apparent dielectric strength with larger sizes of electrode.

After confirming Farmer's results, the authors found that the apparent dielectric strength decreased very slightly if the electrode area were increased by using a "multiple electrode" of small, equal discs connected together by fine flexible copper wires, instead of a single electrode disc of equal contact surface. In order to eliminate effects due to non-uniformity of electric field, the authors' observations are limited to electrode diameters exceeding 20 times the thickness of cambric; the actual thickness of cambric was 0·16 mm. and the minimum disc diam. 1·2 cm. On increasing the electrode area from 1·13 to 18·1 cm.^{2} by changing the diam. from 1·2 cm. to 4·8 cm., the puncturing voltage decreased by more than 18%, whereas the same increase in area effected by using sixteen 1·13 cm.^{2} electrodes, caused only 1% decrease in puncture voltage. This result, which has been checked independently, controverts the "weak spot" theory of the diminished apparent strength.

A given increase in electrode surface with separated small discs results in little diminution of apparent dielectric strength: but if the increased area be obtained by a solid disc or by a metallically framed set of small discs, the diminution in apparent strength is large. Mechanical pressure on the upper electrode does not affect results appreciably. A series of tests outlined in the original lead to the conclusion that when the electrode forms an electrically solid mass the diminution in apparent dielectric strength is large; on the contrary, separating the elements of the multiple electrode electrically, without altering the total active surface, tends to eliminate the reduction in apparent strength. This suggests that the reduction in apparent strength may be due to high-frequency oscillations between the electrodes, through the dielectric. Increasing the diam. of the electrodes would make the free oscillations lower in frequency but larger in amplitude. Air pocketed between electrode and cambric might then be ionised and driven forcibly against the dielectric so as to weaken it rapidly. Multiple electrodes with the elements spread out and interconnected by fine wires offer less opportunity for the formation of air pockets and the development of high-intensity, high-frequency oscillations. Tests with other than brass electrodes corroborate the multiple electrode test. Lead-foil electrodes are found to be remarkably adhesive.

Although observations suggest very high frequency oscillations (perhaps many millions per sec.) as the chief cause of diminished apparent dielectric strength of cambric sheets with increasing electrode area, there is no direct evidence of such oscillations yet available. Testing electrodes should be standardised, and 1 cm. diam. is suggested for cambric not thicker than 0·5 mm. Smaller electrodes do not produce a uniform field and do not cover a representative sample of dielectric. Large electrodes show a too low apparent dielectric strength. R. E. N.

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GENERATORS, MOTORS, AND TRANSFORMERS.

122. *Notes on the Design of Electromagnetic Machines.* **S. P. Smith.** (Electrician, 79. pp. 658–660, July 27; 696–699, Aug. 3; 784–787, Aug. 10; 778–776, Aug. 17; 812–814, Aug. 24; 80. pp. 10–12, Oct. 5; 42–45, Oct. 12; 80–82, Oct. 19, 1917, and pp. 688–686, Feb. 1, 1918.)—This is the second article of the series, and deals with a.c. generators [the first article was referred to in Abs. 701 (1916)]. The first part of the present article deals with the general theory of the alternator, particularly the 3-phase machine, the questions of the choice of the type of winding and the determination of the winding factors being treated by the method developed by the author in an earlier paper [Abs. 288 (1915)]. In the second part of the article a design for a slow-speed alternator is worked out in detail. F. T. C.

123. *Direct Measurement of the Internal Phase-angle of Alternators.* **A. Blondel.** (Comptes Rendus, 165. pp. 1092–1096, Dec. 31, 1917.)—The distortion of the field of an alternator by the load currents causes the position of the poles in space, at any given point on the wave of terminal e.m.f., to vary with every change in the load. To measure the angular change in position the author uses an instrument for producing a spark at a given point on the wave of terminal e.m.f. once every cycle. This instrument consists [see Abs. 85 (1915)] of a magnetised steel tongue, which makes and breaks the primary circuit of an induction coil, when caused to vibrate by an alternating electromagnet fed directly or indirectly from the terminals of the alternator. The secondary spark takes place between magnesium electrodes and illuminates a stroboscopic disc carried on the shaft of the alternator in the neighbourhood of a fixed scale. The make and break magnet must be supplied at strictly constant voltage, and if the e.m.f. wave is impure the harmonics should be filtered out; with careful setting the spark will then occur in each cycle at exactly the same point of the e.m.f. wave. The movement of the stroboscopic figure with respect to the fixed scale, measured in electrical degrees, gives the internal phase-angle. When this angle and the resistance of the winding are known the total equivalent reactance of the alternator, or, as the author calls it, the "torsance," can be determined from the ordinary vector diagram. An alternative device for illuminating the stroboscopic disc consists of a metal lamp with a short, thin filament, supplied from the secondary of a transformer with a highly saturated magnetic circuit, the primary of which is connected in series with a high resistance absorbing nearly all the applied voltage, across the terminals of the alternator. The very peaked secondary e.m.f. gives clearly marked maxima of brightness in the lamp. F. T. C.

124. *Minimum Cost Method of Transformer Design.* **B. C. Dennison.** (El. World, 70. pp. 855–859, Nov. 3, 1917.)—In the method given the magnetic density and the current density are assumed at the outset and the general equations are thrown into forms involving the ratio between the areas of the copper and iron spaces and the ratio between the two dimensions of these two areas. By partial differentiation values of these ratios are obtained which satisfy the conditions of minimum cost or minimum loss, or which give a definite ratio between iron and copper losses. The present article deals with shell transformers with uniform or non-uniform density. F. T. C.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

125. *Practical Calculation of Transmission Lines.* **B. Guerschinovitch.** (Rev. Gen. d'Él. 2. pp. 728–737, Nov. 10, 1917.)—The economic and other considerations bearing on the design of transmission lines are so complex that they cannot be included in any theoretical treatment, but the results of the theoretical treatment of simplified cases can be employed as starting-points for practical design. The author shows by examples the application of the formulæ developed in a previous paper [see Abs. 456 (1917)] to various practical cases. F. T. C.

126. *Corona Tests at High Altitude.* **B. F. Jakobsen.** (Am. I. E. E., Proc. 36. pp. 949–966, Dec., 1917.)—Tests were carried out on a transmission line, 68 miles long, in Peru : the average altitude was 13,500 ft., and the voltages ranged from 40,000 to 72,000. There were two 3-phase circuits, and each has two complete transpositions. The corona losses were found by subtracting from the measured total loss the core and copper losses of the transformers and the copper losses due to the charging currents. The methods by which these losses were determined are explained. The results are shown in the following table, where the corona losses, as measured by these methods, are given in column 3. The figures obtained by calculations based on Peek's law are given in column 2.

Line Kv.	Peek's Law. Kw.	Jakobsen. Kw.	Ratio.
50·5	0	6·0	—
54	22	9·6	2·29
58	100	17·5	5·72
62	286	31·5	7·49
66	428	57·5	8·31
70	678	105·5	6·42
72·3	848	153·0	5·54

From this it will be seen that there is a wide discrepancy between the results obtained by the present method and those shown by Peek's law, amounting in one instance to 800 %. There is, however, a very fair agreement with the results obtained by Faccioli on the Shoshone–Leadville line. This seems to show that the loss-voltage curve is logarithmic and not quadratic for the voltage-range under investigation. A note by Ryan on the results is added, and a comparison is also made with a formula due to Ryan : in this latter case there is found to be no great discrepancy. The losses, due to corona, have in fact turned out to be less than was expected on this line ; this fact influences to some extent the size of wire to be chosen, and is thus of practical importance. Tests were also carried out in rainy weather, but there was no appreciable difference from the results obtained in fine weather. W. H. S.

127. *Voltage-drop in Unsymmetrically Spaced Conductors.* **G. S. Humphrey.** (El. World, 70. pp. 1097–1100, Dec. 8, 1917.)—When the conductors of 3-phase circuits are supported equidistantly from one another and the load is balanced the voltage-drops are equal in the conductors. The

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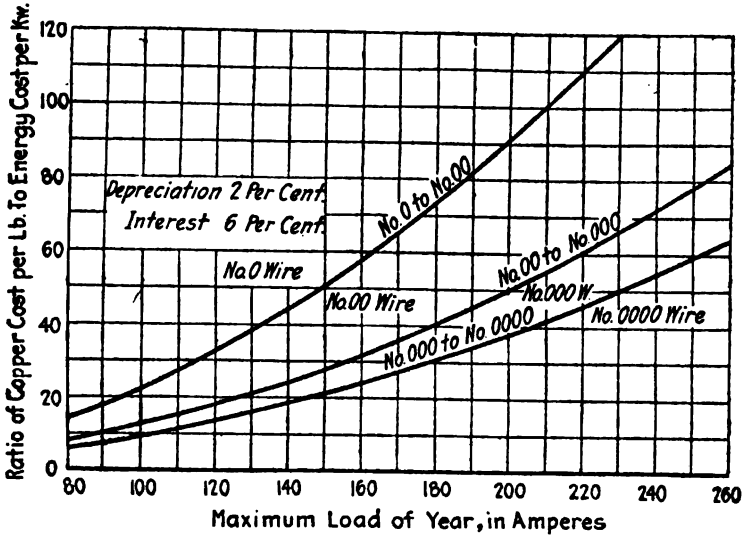
load is, however, often not balanced, and in most distribution lines the conductors are not arranged in the form of an equilateral triangle. The article describes methods to determine the voltage-drops in cases of this kind. In a single-phase circuit the reactance in ohms per conductor per 1000 ft. at 60 cycles per sec. is given by $X = 0{\cdot}5275 \log_{10}(D - r)/r + 0{\cdot}00578$, where D is the distance between conductors and r is the radius of the conductors. If a 3-phase line consists of three lines unequally spaced carrying unequal currents, the reactive drop in the line 1 may be obtained by the above formula as the vectorial sum of two portions as follows: If X_2 is the reactance of 1 with respect to 3 and X_3 the reactance of 1 with respect to 2, and if I_2 and I_3 are the portions of the current in 1 that flow in 2 and 3 respectively, then the reactive drop in 1 is the vectorial sum of the drops I_1X_1 and I_2X_2. A number of special cases are worked out, applying this fact both by employing the method of complex quantities and the method of vectors. It is shown that there is less unbalancing of voltage on 3-wire mesh-connected circuits than on 4-wire star-connected circuits similarly loaded, but that there is a greater unbalancing in the phase-angles between the voltages in the 3-wire system. Greater care is necessary in the 4-wire circuit to ensure equal balancing of the loads on the three phases. With suitable spacing of the conductors balanced voltages may be obtained with unbalanced loads. Balancing may be aided by the use of compensated single-phase regulators, or by the use of banks of transformers connected in mesh on the secondary sides. A. J. M.

128. *Methods of determining Economical Feeder Sizes.* **P. O. Reyneau.** (El. World, 70. pp. 1142–1144, Dec. 15, 1917.)—The total annual losses in a



line can be calculated in terms of the max. current when the character of the load is sufficiently well known, and the most economical feeder is that for which the cost of the energy loss is equal to that part of the total fixed charges on the line which is influenced by the section of copper installed. If two lines of different section be compared it will be found that for any given value of the max. load there will be a certain ratio between the cost of copper and the cost of energy which makes the annual cost the same for both

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lines. The curves of the Fig. have been obtained on this principle; the uppermost curve shows the relation between cost ratio and max. load (of an assumed character) which would be met equally well by a No. 0 and a No. 00 wire; the middle curve applies similarly to No. 00 and No. 000. Any combination of cost ratio and max. load corresponding to a point lying in the region between the two curves will be met best by No. 00 wire. F. T. C.

129. *Catenary Overhead Construction.* **W. C. Lancaster.** (El. Rly. J. 50. pp. 1024–1029, Dec. 8, 1917.)—This is an account of the methods of construction and design adopted at the Montreal terminus of the Canadian Northern Railroad and in the tunnel leading thereto. The conditions are severe, as the temperature varies from —35° F. to 110° F. Wooden poles of Eastern white cedar are used, and are set 7 ft. in the ground; they are 150 ft. apart on tangents and 120 ft. on the curve on single track: on the double track, where the overhead clearance is limited, the spacing is 105 ft. on tangents. A steel messenger wire is used, anchored every half-mile. Strain insulators are of the "goose-egg" type in two sizes: on the bracket construction there are double petticoat porcelain insulators of the pin type: the messenger rests in the groove at the top of this insulator and is not tied except at curves. The contact wire is of bronze, which is expected to have a longer life than hard-drawn copper and can be pulled up tighter. The height of the trolley wire above the track is 23 ft., except on the double track and in the tunnel, where it is 16 ft.; on these latter sections two wires are used over each track. The use of a steel contact wire was considered, but its possible advantages were considered too small. The hangers are of the long-loop type: in spans of all lengths from 150 ft. to 90 ft. the hangars are 15 ft. apart. Lightning arresters of the magnetic blow-out type are installed at half-mile intervals; in addition, aluminium cell arresters are installed in the substation on the positive bus-bars and on the feeders. A final section of the paper gives the data on which the calculations for the design of the construction were based, and from which the necessary strength of the messenger for the different lengths of span was determined. In the tunnel the messenger wire is of phosphor bronze; it is supported at 90-ft. intervals from the roof of the tunnel by a combination of iron yokes held in the concrete by four 1-in. bolts. Two phosphor-bronze trolley wires hang side by side from the messenger. The two hangers nearest the messenger support are made with two loops, one sliding inside the other, so that the top loop cannot rise over the messenger, where the clearance to the roof is very small. W. H. S.

130. *Protection of Generating Stations against the Effects of Short-circuits.* **F. Scoumanne.** (Rev. Gén. d'Él. 2. pp. 215–227, Aug. 11, and pp. 255–268, Aug. 18, 1917.)—The article commences with a description of the generating stations in the district of Baku with a total output of 160 million kw.-hrs. per annum. The area is supplied from two generating stations at Ville-Blanche and Bibi-Eibat. The former station supplies Balakany with power over an aerial line and the latter its own district by underground cables, while the two stations are interconnected by an aerial line. The generators are 3-phase, 50-cycle, 6000–6600-volt machines. The transmission is effected partly at 6000 volts and partly at 20,000 volts. A number of typical accidents are described that result from the magnitude of the installations involved. They are divided into two groups, according as they relate to deformation of conductors or breakdowns in oil-switches. The former include deformations in the reactive coils of lightning conductors, tearing of conductors from their

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supports, and bending of bus-bars and leads leading to the oil-switches. The failures in oil-switches were caused by damp weather following a dry period in which much dust had collected in the chambers containing the oil-switches and in another instance by the opening and closing in quick succession of an oil-switch by the attendant in an endeavour to localise a fault to earth. The causes of and the remedies for such breakdowns are examined, and it is concluded that the best means of counteracting the effects of failures of the first type is by anchoring all conductors very firmly. So far as the explosions in oil-switches are concerned, Klingenberg has advocated their complete removal, but the author thinks that this remedy is associated with other drawbacks. He discusses the magnitude of the power developed at oil-switches, and comes to the conclusion that the best measures to take are to sectionalise the station and the network, diminish the apparent power of the generators, and reduce the magnitude of the short-circuit currents by the use of reactive coils. Each of these palliatives is discussed in detail. The sectionalising in the substations is carried out by the aid of auxiliary bus-bars, each supplying separate feeders, that can be connected to various sections of the main bus-bars or in parallel with one another. In the generating station there are two sets of bus-bars, so that the station may operate as two completely separate units or as one unit, if the bus-bars are connected in parallel. It is admitted that these arrangements complicate the operation of the station. The action of oil-switches is improved by raising the power-factor of the load and synchronous motors are installed to carry this into effect. The question of the best manner of using current-limiting reactances is dicussed in great detail, and it is proposed to apply them on a large scale in the Ville-Blanche station. They will be placed at the points of departure of cables and between the various sections of the bus-bars. It is shown that it is generally possible to adjust the circulating current between the different bus-bar sections so that it may be nearly in phase with the bus-bar voltage, and thus reduce the voltage-drop caused by the coils to a very low value. The article concludes with a description of the construction of the substations with the particular aim of limiting the area affected by any short-circuits that may take place. The stations are sectionalised into fire-proof compartments in three floors, the high-voltage apparatus at 20,000 volts being on the top floor, the moderate voltage apparatus at 1000 volts on the middle floor, and the synchronous motors on the ground floor. An annexe comprising two floors contains the transformers on the ground floor and an empty space in the upper floor; this latter acts as a passage to carry off any gases that are developed by explosions in the oil-switch chambers that communicate into it through hinged doors normally held shut by springs.

A. J. M.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

131. *Electric Traction in Salt Lake City.* (El. Rly. J. 50. pp. 1070–1071, Dec. 15, 1917.)—The Salt Lake, Garfield, and Western Railway is being electrified and extended to the American Smelting and Refining Co.'s works, making a total of 20 miles of single track. A special feature of the installation includes the use of automatic substations, equipped with motor-generator sets for supplying power to the trolley at 1500 volts: previously, rotary converters have always been used in automatic substations. Energy is being purchased from the Utah Power and Light Co., which has a 44,000-volt transmission line along the side of the railway. Each substation contains a

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motor-generator set, made up of a 900-h.p., 3-phase, 60-~ induction motor, direct-connected to a 600-kw., 1500-volt, compound-wound d.c. generator. The General Electric Co. will supply the automatic substation equipment, but no particulars of this feature of the installation are given. The cars are equipped with 1500-volt motors, but can also be worked on the 525-volt system of the Utah Light and Traction Co. in Salt Lake City. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

132. *Voltage-rises in Third-rail Circuits.* **D. D. Ewing.** (El. Rly. J. 50. pp. 1072–1075, Dec. 15, 1917.)—The inductive effects in third-rail practice have increased as the result of increases in pressure and current. Thus it is not uncommon for a motor flash-over on the interruption of a heavy current on one car to cause trouble on other cars in the neighbourhood. The author calculates and measures the fluxes in megalines per 1000 ft. of track per 1000 amps. in the third rail: the calculations are based on certain theoretical assumptions as to the distribution of the flux and the nature of the cross-sections of the rails. The actual fluxes were measured by test coils, and agree fairly well with the calculations based on three different assumptions. He then proceeds to calculate and measure the induced voltages, and to give oscillographic records. Under short-circuit conditions, when practically the whole station voltage is absorbed in resistance drop, it may be expected that the voltage-rise, incident to the interruption of the current, would be two or three times the normal station voltage. W. H. S.

133. *Field Control for Exciting Traction Equipments.* **W. P. Jackson.** (El. Rly. J. 50. pp. 1081–1082, Dec. 15, 1917.)—The author points out the advantage of being able to run temporarily at high speed without employing special gear ratio. The shunt field equipment described can be fitted to existing equipments by hanging it on the under-frame with four bolts and making eight electrical connections to existing control circuits. The weight of the special equipment is 104 lbs. per car complete; no changes or additions are required on the motors or controllers. Installation of automatic field control on the 87,800-lb. cars of the San Francisco–Oakland Terminal Rly. increased the max. speed of cars from 22½ to 28 miles/hr., and has done much to improve the maintenance of schedule speed. Field control gives all the benefits obtainable by the use of max. gear ratio, both where stops are frequent and where there are opportunities for free running at high speed.

In the equipment described, two contactors shunt the motor fields through a grid resistance which may be varied to obtain the most economical max. speed for a given schedule. The contactors are operated by the p.d. across No. 1 armature motor, and are set to operate only above 800 volts. This prevents the fields from being shunted on the series running position. The operating coils of the contactors are controlled by a relay which may be set for any value of No. 1 motor current between 60 and 120 amps. The No. 1 coil on the relay holds the latter open until all the motor resistance has been removed; the field circuits cannot be shunted until the controller is on the last notch and the motor current has fallen to predetermined value. The field control equipment described may be applied without regard to the type

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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of control and motors used. Also, it may be adjusted to suit a given schedule, in respect of max. speed and current at which shunts are connected. The fields may be shunted in about 7 secs. from the first notch on level track, the controller being ordinarily moved from first to last notch in 5 or 6 secs.

R. E. N.

ELECTRIC LAMPS AND LIGHTING.

134. *Double-arc Lamps for Low-frequency Three-phase Working.* **A. Blondel.** (Rev. Gén. d'Él. 2. pp. 975–981, Dec. 22, 1917.)—The author describes constructions and connections permitting an arc lamp to be operated on low frequency, 3-phase supply without unbalancing the latter or showing fluctuation of light. A simple means is described which eliminates difficulties due to the use of several arcs of different phases in the same lamp.

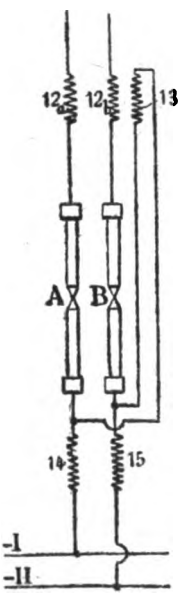

FIG. 1.

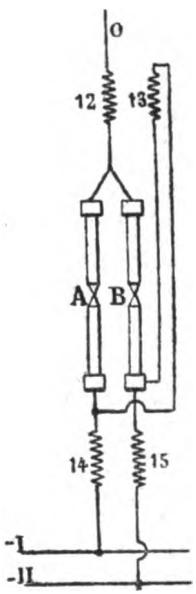

FIG. 2.

The use of Scott transformers simplifies the construction of the regulating coils in the lamp, and permits the latter to work on 3-phase supply with only two pairs of carbons. An ordinary a.c. arc gives disagreeable "palpitations" of light when working on 25-~ supply. Two arcs connected to the two phases of 2-phase, 25-~ supply yield a total illumination in which there are 100 pulsations per sec. The amplitude of these pulsations is much less than in a single lamp on 50-~ supply. The net illumination from 2 or 3 arcs of different phase is more uniform and the equipment is more convenient, if the arcs be arranged in a single lamp. The cost and complication of a separate regulating mechanism for each arc are not justified. What is required is a single simple mechanism which will maintain two or three arcs with certainty.

By using only 2 arcs for 3-phase working, the author simplifies and cheapens the lamp and prevents it from becoming an inconveniently

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powerful lighting unit. Two pairs of carbon-holders are hung over drums on the spindle of a rocking frame and a ratchet mechanism is incorporated so that a single regulator normally controls both pairs of carbons at once, yet either pair has freedom to move together until contact is re-established after an interruption. This feature provides for the possibility of uneven burning, without complicating the normal regulation.

The author shows connections for the new lamp with various supply systems. An important simplification (more mechanical than electrical) is to wind series coils (or shunt coils) concentrically where possible, instead of using two sets of magnets and plungers. Fig. 1 shows connections for two lamps on 2-phase, 4-wire supply. A, B represent the two pairs of carbons; I, II the two supply phases; 12*a*, *b* the series, and 18 the shunt regulating coils; and 14, 15 represent series resistances or choking coils. If the two phases have a common return, the latter may be connected to both the upper carbons (Fig. 2) through a single series coil 12. Two double-arc lamps thus connected may be operated in series on 2-phase, 4-wire supply. By using the Scott tee-transformer, 2-phase current may be obtained from 3-phase supply, and used as above to operate a double-arc lamp. For a series lighting system the 3-phase primary windings of the Scott transformer are connected in series with the line. The cost of transformers is offset by the practicability of using 2000–5000 volts for the transmission. Whether for 2-phase or 3-phase supply the new lamps are no more complicated than a lamp with one arc, very steady illumination is obtained, and the free-wheel device for re-striking the arcs is so rapid and effective in action that the momentary extinction can hardly be detected. R. E. N.

135. *Tungsten Filaments.* **Schröter.** (Elektrot. u. Maschinenbau, 35. pp. 501–505, Oct. 21, 1917. Paper read before the Deut. Beleuchtungstechn. Gesell., May, 1917. Elekt. Zeits. 38. pp. 506–508, Oct. 18, and pp. 516–517, Oct. 25, 1917.)—A lecture on the process of J. Pintsch [see Abs. 346 (1917)]. No further technical information is given, but reference is made to the researches of J. P. Valeton (Sächs Gesell. Wiss. Ber., 1915) on crystal form and solubility, and of others with regard to possible explanations of the long tungsten crystals and the action of the thoria. Rinne and Gross are studying the crystal structure of the filaments by X-ray examination after Laue and Debye. H. B.

136. *Adapting 220-volt Circuits to 110-volt Lamps.* **J. R. Colville.** (El. World, 70. pp. 1189–1190, Dec. 22, 1917.)—Lamps rated at 110–125 volts are more satisfactory than those designed for 220–250 volts; they are more efficient, give longer life, and are lower in price than the high-voltage type. The total saving under these headings will generally pay, in a few months, for the cost of changing over from 220–250 volts to 110–125 volts, a balancer coil or motor-generator being installed for the purpose. The difference in first cost of the lamps ranges from 4 cents per 25-watt lamp in a $10,000 contract (6 cents on list price) up to 94 cents per 1000-watt gas-filled lamp in a $10,000 contract ($1.40 per lamp on list price). Approximately, 230-volt lamps are 20 % more costly than 115-volt lamps, and yield only 90 % as much light for equal wattage. When laying out a new installation, the use of 110–115-volt lamps often yields sufficient saving in the aggregate wattage and in the number of reflectors and sockets, etc., to pay for the installation of voltage-reducing equipment. The annual saving in energy and lamp renewals is then pure profit. Burning lamps in series means that when one fails the other is extinguished; also slightly less than normal life is to be expected from lamps

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burning in series. In an industrial installation it is worth while to provide a balancer coil, motor-generator, or other voltage bisecting device. Excluding miniature lamps, 110–125-volt lamps form 85 % of the output of Mazda factories, compared with less than 7 % for 220–250-volt lamps. The lower-voltage lamps are more highly standardised, and improvements are more easily incorporated. R. E. N.

137. *Oxygen-filled Tungsten Lamp.* (U.S. Pat. 1,240,700. El. World, 70. p. 854, Nov. 3, 1917. Abstract.)—This patent of E. Friederich's relates to a method of overcoming the deterioration set up by current discharges through chlorine vapours evolved from substances introduced into lamp bulbs to prevent blackening. The tungsten filament burns in an atmosphere containing oxygen at low pressure, which does not appreciably attack the incandescent tungsten but in the colder zones of the lamp oxidises the vaporised tungsten to tungsten trioxide. The oxide is not volatile, and is deposited on the glass bulb, but is practically colourless. The pressure at which the oxygen is introduced is usually less than 0·0001 mm. It is desirable to introduce substances capable of evolving oxygen to replace that originally present in the bulb. Among such substances manganese superoxide and barium chlorate are especially suitable. J. S. D.

138. *Combined Refractor and Diffusing Globe for Street Lighting.* **W. Harrison.** (Illum. Eng. Soc., Trans. 12. pp. 805–809; Disc., 809–818, Oct., 1917.)—The trend in street lighting during recent years has been towards units giving a greater proportion of the total light-flux in zones slightly below the horizontal. In this way we can increase the illumination in the region half-way between two lamp-posts, which is usually not more than 5 to 10 % of the average value over the street-surface illuminated. Some prefer fixtures utilising opal globes, on the ground that refractor devices give rise to glare; that much of the light from them fails to reach the street-surface and is thus wasted; and that the illumination at the foot of such units is disproportionately low. The opal globe is less subject to these defects, but it does not yield the desirable distribution-curve for street lighting, and is said to be deficient in revealing smaller obstacles and irregularities on the road-surface. The unit described by the author is a combination of the diffusing-globe and refractor methods. The desired distribution of light is achieved by a two-prismatic dome refractor which bends the rays of light obliquely, and a stippled outer globe is employed to promote diffusion of light. Polar curves are given illustrating the performance of this unit with a 20-amp. gas-filled lamp of 1000 c.p. rating, and emitting 10,000 lumens at 518 watts consumption. At 75° angle 1800 c.p. is emitted, and the intensity at angles slightly below the horizontal is high. Corresponding curves for the old type of refractor and the opal globes are presented. The unit is suitably designed with a view to ventilation, is weatherproof, and is easy to clean. In the *discussion*, it was pointed out that the polar curve departs more widely from the ideal form giving uniform illumination from two lamps at a specified distance apart than was the case with the original refractor unit. But the accentuation of light in the 75°–90° zone is greater. J. S. D.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

MARCH 1918.

PRIME MOVERS.

STEAM PLANT.

139. *Joliet High-pressure Steam Plant.* (El. World, 71. pp. 146–148, Jan. 19; 193–195, Jan. 26, and pp. 242–244, Feb. 2, 1918. Power, 47. pp. 108–113, Jan. 22, 1918.)—The Public Service Co. of Northern Illinois have completed the first unit of a new power house near Joliet. One 10,000 kw., 12,000-volt turbo-generator is at work and another is being erected. The final capacity of the plant is to be 60,000 kw. or more. The boilers, which operate at 325 lbs. per sq. in., are of the ordinary B. and W. cross-drum type, with heating surface of 9919 sq. ft., superheater 3100 sq. ft. and economiser 6780 sq. ft. Each boiler occupies 294 sq. ft. floor-space and has a grate area of 282 sq. ft. in two chain grates. Stokers and fans are motor-driven. A self-supporting steel stack, 7 ft. in diam., rises 125 ft. above the grate; it is unlined as the flue gases leave the economiser at only 350° F., but is painted with heavy asphaltic paint. The economiser is constructed like an ordinary B. and W. boiler, but has no drums, with wrought steel headers, and tubes 16 ft. long × 4 in. diam. of drawn steel ¼ in. thick galvanised inside and out. The fan has a rated capacity of 75,000 cub. ft. per min. of gas at 358° F.; the power required is 94 h.p. A sectional elevation shows the plant arrangement. The electrical distribution is at 12,000 and 33,000 volts, 3-phase, 60 ∼. The generator windings, Y-connected, give 13 % inherent reactance to each machine, and each neutral point is connected through a non-automatic oil switch to a common earthing bus-bar, earthed through a resistance. An automatic regulator controls the generator pressure. The equipment of the main switch-house is on four levels. Each generator feeds through either of two oil switches to a double bus-bar system. The switchgear is described and a key diagram shows the principal circuits. Control is effected from the operating room on the turbine-room floor level. A 40-amp.-hr. (8 hour) storage battery is installed for emergency lighting and pilot lamps. W. N. Y. K.

140. *Feed Arrangements for Turbines having a Steam Velocity greater than that of Sound.* G. Zerkowitz. (Zeits. Vereines Deutsch. Ing. 61. pp. 869–873, Oct. 27, and pp. 889–892, Nov. 3, 1917.)—The present papers contain a critical examination of the conditions prevailing in the inlet of

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steam turbines working at velocities exceeding that of sound. The form of the radial deflection of the inlet current of steam was determined for the cases of an ordinary parallel-walled pipe and a de Laval nozzle. The experimental procedure adopted is described in detail. It was found that, at the diagonal-cut, there was at one time the behaviour of an enlargement, at another time of a constriction. The case of free expansion was studied and a relation obtained for the average deflection which shows a noteworthy agreement with radial diagrams already in existence. It appears that the average deflection hereby arising is smaller than that given for a simple expansion from a point—a circumstance which is of value for the case of slot-expansion. Finally the procedure during expansion from a point was examined and graphed. From the results the deviations which occur with ordinary feed apparatus were established, and a method of adjustment thereby indicated for obtaining a uniform deflection of all stream lines when the steam velocities are greater than that of sound. H. H. Ho.

141. *Saving due to Automatic Combustion Control.* **I. L. Kentish-Rankin.** (El. Rev., Chicago, 72. pp. 64–66, Jan. 12, 1918.)—In a plant with two 480-h.p. Heine and one 250-hp. Jumbo boilers, handfiring and natural draught, a balanced draught system was fitted in order to reduce working costs and to indicate if it would be justifiable to fit machine stokers. The equipment comprised one balanced-draught gas-pressure regulator for each boiler, one 7-h.p. engine-driven blower, and one steam-pressure regulator. The gas-pressure regulator, actuated by the pressure in the furnace, controls the air inlet and flue outlet dampers. When the furnace-pressure changes the outlet damper is moved to oppose it. The blower, regulated by the steam-pressure, is able to supply a constant volume of air at variable pressures for a definite speed. The improvement in results obtained due to the new equipment is shown in the table :—

	Natural Draught.	Balanced Draught.
Date of test	June 29	July 29
Coal used	Youghiogheny screenings	50 % same + 50 % anthracite dust
Average steam pressure, lbs. per sq. in.	134·4	134·7
Average feedwater temp., °F.	148	135·8
Average flue gas temp., °F.	585	548·0
Total weight, water measured, lbs.	287,406	265,968
Total weight, water evaporated (212° F.)	287,265	266,359
Total weight, dry coal fired, lbs.	88,570	·31768
Total weight dry ash and refuse, lbs.	4752	4172
Percentage dry ash and refuse, lbs.	12·8	13·1
Water evaporated per lb. coal (212° F.) (as fired)	7·81	9·01
Water evaporated per lb. coal (dry) (as fired)	8·81	9·41
Efficiency, boiler and furnace %	60·9	70·5
Flue-gas analysis, average % CO_2	6·7	12·4
Cost per 1000 lbs. water evaporated (coal as fired, Youghiogheny at $2·50 and anthracite dust at $1·00 per ton)	16 cents	9·76 cents
Percentage saving	—	39·0

W. N. Y. K.

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142. *Coordinating Furnace Requirements with Boiler Performance.* **L. Linnell.** (El. Rev., Chicago, 72. pp. 121–122, Jan. 19, 1918.)—Argues that for a given rate of steam-making there is a definite rate of coal consumption, which means a corresponding thickness of fuel bed, and for this there is a definite percentage of CO_2 and air supply. For a given coal a certain excess of air gives the best efficiency, and this should be determined by testing with a CO_2-recorder. Then the air pressure, by draught gauge, bears a direct relation to the CO_2 percentage, for a given equipment and set of conditions. Hence, for a given rate of steam-making, the corresponding draught and thickness of fuel-bed to obtain the highest efficiency can be indicated by the pointer on the steam-flow meter, in scales proportioned to the steam flow. A meter calibrated in this way is illustrated. W. N. Y. K.

143. *Boiler-room Efficiencies.* **G. F. Weaton.** (Power, 47. pp. 98–99; Disc., 99–101, Jan. 15, 1918. Paper read before the Providence (R.I.) Eng. Soc., Dec., 1917.)—Suggests methods of increasing the efficiency of steam-raising by the design and lay-out of boiler-rooms, especially in regard to economising labour which is now high-priced and inefficient. Oil as fuel has many advantages over coal, but the supply is unreliable and transport is costly. The control of combustion should be as automatic as possible. An Orsat apparatus gives the amount of CO_2, CO, and O in the flue gases, hence it is preferable to a CO_2-recorder. By experience the conditions of combustion can be very accurately gauged by observing the colour of the flames through dense violet-blue glasses. In the *discussion*, **H. A. Wilcox** said that in designing a plant the nature of the industry must be considered as to hours of working, use of exhaust steam, etc. W. N. Y. K.

144. *New Method of increasing Evaporation in Boilers.* **C. Hering.** (Power, 47. pp. 10–13, Jan. 1, 1918.)—When very hot gases impinge upon the surface of a water-boiling vessel, a thin film of gas, offering an enormously high resistance to the passage of heat, forms on the surface. If the flame temperature is about 2462° F. and that of the water is 212° F. there is a fall of about 2250 deg. F. through the film, which appears to be only about 0·005 in. thick. The resistance was found to diminish rapidly when the temperature-difference between the flame and the metal was reduced. To effect this reduction it was sought to increase the temperature of the flame side of the vessel by interposing a thermal resistance, by attaching lugs to it. Researches show that when the flame side is maintained at, say, a dull red-heat the film resistance is reduced by a far greater amount than the artificial resistance added, therefore there is a great gain in the flow of heat. Curves from the results of tests show that with lugs of the same diam. and increasing lengths the rate of heat-flow is increased up to a certain point and then decreases. The best condition would appear to be one lug of the diam. of the bottom of the vessel, *i.e.* a very thick bottom, or thick-walled boiler tubes, but this is impracticable. The other extreme is to have innumerable very thin short lugs, but this is costly and weak in structure. Between the extremes are mean proportions which give good results. The investigations were carried out in open flat-bottomed tin cups with lugs of varying lengths and diameters; the same quantity of water was evaporated in each with the same large quiet bunsen flame, and the time was noted.

W. N. Y. K.

145. *Boiler Efficiency by CO_2 Analyses and Flue Temperatures.* **H. O'Neill.** (Power, 47. pp. 52–55, Jan. 8, 1918.)—Gives a chart by means of which the

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efficiency of a boiler can be determined when the flue-gas temperature and percentage of CO_2 at the boiler exit are known. It is assumed that these two factors are the only variables concerned, and the error involved does not usually exceed 2·5 % where Eastern (U.S.A.) coals are burned. A number of charts are given showing the relation of hydrogen to CO_2 with various amounts of excess air, also heat losses of various kinds, which are discussed.

W. N. Y. K.

146. *A Review of a Series of Manuals on Heat-drop Tables.* **J. A. Ewing.** (Nature, 100. p. 481, Feb. 21, 1918.)—Two of the books on "Heat-drop Tables" are by H. Moss; the third, on "Correction Tables for Thermodynamic Efficiency," is by C. H. Naylor. They are founded on the calculations of H. L. Callendar, and have been compiled at the instance of the Turbine Section of the British Electrical and Allied Manufacturers' Association.

Since data which have come down from Regnault and Rankine and quoted in all engineering text-books are erroneous and incomplete, the present volumes accepting Callendar's values of the properties of steam as authoritative are especially welcome. The reviser points out that, like so many other British initiatives, the new departure found its earliest practical development in Germany. The "heat-drop" with which these books are concerned is the change that occurs during adiabatic expansion in one of the properties of steam, namely, the function $E + PV$ to which Callendar in 1908 gave the now generally accepted name of "total heat." It is the function which does not change when the fluid is forced through a throttle-valve or porous plug. In adiabatic passage through an engine, on the other hand, the total heat changes by an amount which directly measures the work done. Consequently the heat-drop between admission and exhaust is a measure of the utmost amount of work that can be obtained from steam in passing through a turbine or any other form of engine. Hence its great importance in the design of such engines and its like importance in connection with practical problems of refrigeration. The reviewer points out the connection with the philosophical abstractions of Willard Gibbs, since the heat-drop is identical with one of his thermodynamic potentials χ. The reviewer also comments adversely upon the retention of the Fahrenheit scale of temperature.

H. H. Ho.

147. *Safety Devices for Steam Turbines.* (Engineer, 125. pp. 58–59, Jan. 18, 1918.)—The working and construction of some safety devices for steam turbines designed by the Oerlikon Co. are described and illustrated. A drainage system, to avoid corrosion consequent upon leaky joints in the condenser, is shown. The condensation water is drained away whether the turbine is running or at a standstill. The main governor is illustrated. Steam control valves are actuated by pistons under oil pressure. There is a "toothed" oil pump coupled directly to the governor spindle, to obtain slow speed and reliability. If the oil pressure falls to 22 lbs. a safety device shuts the main steam valve, thus preventing any damage to the bearings through failure of lubrication. An emergency governor on the end of the main shaft shuts down the turbine if the speed rises about 15 % above the normal; another emergency governor on the governor spindle acts on the oil flow to the piston controlling the steam valve, shutting steam off in case of excess speed. A third governor is mounted on the bottom end of the governor spindle, operating on the main valve if the excess in speed is 20 %. A new safety device instantly closes the main steam valve if the rotor moves

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axially a small amount, say 1·5 mm. The method of starting up the turbine and the action of the various devices are given in detail. W. N. Y. K.

148. *Moloch Stoker Improvements.* (Power, 46. p. 784, Nov. 27, 1917.)—A new device for timing the strokes of the ram in the Moloch underfeed stoker is described and illustrated. It consists of an automatic cut-off valve actuated by the timing device operated in conjunction with the forced draught, and regulated by the steam demand on the boiler. The timer is a pilot valve of the rotary disc type with four ports controlling steam admission to the main valve on the stoker. The strokes of the ram are controlled from 0 to 200 per hour by setting a handle on the face of the timer. Its working and also its economy in steam are described. [See Abs. 165 (1917).] W. N. Y. K.

149. 200,000-*Ton Coal Storage Pit.* (El. Rev. and West. Electn. 71. p. 607, Oct. 6, 1917. Power, 46. pp. 650–652, Nov. 13, 1917.)—The Duquesne Light Co., Pittsburg, has constructed the largest submerged coal basin in the world at the Brunot's Island plant as a precaution against fire risk. It is to supply a 68,000-kw. generating station on the Ohio River. The basin is connected to the river through four shafts with both gate and check valves in the bottom of wells. The side walls are at an angle of 45°, curved at the bottom. They are 18 in. thick at the bottom and 8 in. at the top, reinforced with steel bars and expanded metal. The floor is in sections about 40 ft. square separated by curb walls 18 in. high, with pitch and tar paper joints to allow for expansion and contraction. The side walls are also in sections. The basin is served by one 175 ton-per-hour electric link-belt crane, 110 ft. radius, and one 50-ton link-belt locomotive crane. W. N. Y. K.

150. *Lubrication of Motor-driven Air Compressors.* (El. Rev. Chicago, 71. pp. 758–762, Nov. 3, 1917.)—Gives a summary of a treatise prepared by the Lubrication Engineers Assoc. of the Texas Co., New York.

The final temperature developed theoretically by a volume of air under compression is tabulated thus :—

Gauge pressure, lbs. ...	0	25	50	75	100	125	150	200
Atmospheres	1	2·7	4·4	6·1	7·8	9·5	11·2	14·6
Final temperature, ° F.	60	284	389	420	485	540	589	672

In practice temperatures are kept lower than these values by the use of coolers. The internal lubrication requirements differ from those of steam engines, precluding the use of compound oils; also compressors require less oil. Low speed and heavy pistons require higher-viscosity oil than high speed and light pistons. Other important factors are the degree of compression, position of air inlet, method of applying lubricant, kind of valves, water jackets and intercoolers. Vertical compressors require less and lighter lubricants than horizontal ones. Carbon deposits are probably the chief cause of explosions, as they increase friction and raise the temperature of the air. A simple method of testing the suitability of oils is described. A cast-iron block, 6 or 8 in. square by 2 in. thick, has its upper surface polished, and a hole ¼ in. deep for a thermometer bulb drilled in. The block is heated to 400° F. in a layer of sand in a shallow iron pan. One drop of the oil to be tested is allowed to fall on the surface of the block, and its properties as to spreading, drying, and residue indicate its usefulness or otherwise. The lubrication of a compressor in connection with a Diesel engine, and the causes of explosions are discussed. W. N. Y. K.

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151. *Michell's Automatic Lubricating Gear.* (Engineering, 104. pp. 548–549, Nov. 26, 1917.)—A description is given, with illustrations, of a new type of apparatus for automatically lubricating bearings during starting and stopping, without the use of any auxiliary driving power. A specialised accumulator is actuated entirely by the flow of oil maintained under pressure between the working surfaces of the bearing during running at normal speed. The top brass of the bearing is pivoted on a hollow stud making oil-tight contact with it; a hole is drilled through the brass to the working face at or near where the oil pressure is a maximum. Normally oil is supplied through the stud at a pressure of, say, 900 lbs. per sq. in. from an accumulator, or intensifier. When the shaft stops a detent nut holds the plunger so that no pressure is put on the oil. When the handle is moved to start the machine the detent is released. The large chamber of the accumulator discharges into the well of the bearing and the whole tension of the loading springs increases the oil pressure in the small chamber to, say, 2500 lbs. per sq. in. Oil at this pressure is discharged back to the bearing, forming a film between the surfaces. Tests have shown that the coefficient of friction with this apparatus is 0·01, as compared with 0·18 without it, under usual conditions of starting. The pressure in the accumulator is also used for forcing the oil through a filter and cooler, if required. One accumulator may supply several bearings if a charge-limiting valve is fitted to equalise the distribution of flow. W. N. Y. K.

152. *Temperature Control for Superheated Steam.* **H. Huebner.** (Zeits. Vereines Deutsch. Ing. 61. pp. 885–888, Nov. 3, and pp. 921–924, Nov. 17, 1917.)—It is impossible to obtain precisely the desired superheat unless some means of control is provided. The dryness factor of steam leaving the boiler depends on the water circulation, which latter, even in the same boiler, varies with load and other factors. The heat transmission factor is commonly taken to vary only with the velocity of the gases, but the temperature difference between gases and steam has undoubtedly an important effect. Even were a completely reliable formula available it would still be impossible to determine the actual value of all the variables and to realise exactly the anticipated superheat. The steam temperature varies with the length of flame; and a higher temperature is reached with mechanical stoking and ash removal than when doors are opened frequently for manual attention. Temperature and quantity of flue gases, and dryness of steam vary considerably with the load on the boiler.

The effect of the superheater may be controlled by dampers, by water-cooling, or by varying the moisture content of the "saturated" steam. Control by dampers is used most frequently, but this is not the best system. It is true that damper control strikes right at the root of the matter by cutting off flue gases more or less completely from the superheater, but the damper doors are heavy to move and require massive supports, also they depreciate rapidly in service. The author illustrates several arrangements of swinging dampers and discusses their merits and defects. In one good form, the dampers are not exposed to the hottest gases. It is generally easier to accommodate the dampers in water-tube boilers with vertical or steeply inclined tubes. Sliding dampers of refractory material are more durable and reliable than pivoted metal dampers in boilers with very high superheat. By-pass openings with refractory shutters may be used to allow more or less of the flue gases to escape without passing through the superheater; the by-pass is adjusted to give correct superheat on normal load.

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On the other hand, the use of a by-pass involves some sacrifice of boiler efficiency even though the hotter emerging flue gases be passed through an economiser. Any arrangement of dampers which involves providing a second gas path below the superheater, necessitates higher and more costly boiler setting and boiler house.

The Babcock and Wilcox temperature control uses the boiler water to cool the superheated steam to the desired temperature. This system is conveniently efficient and gives accurate control over a wide range without wasting space. A 8-way valve is used to determine the proportion of the superheated steam that is passed through the cooling pipes in the boiler. The steam temperature in the superheater itself is unaffected by this system of control and should therefore not exceed 480° to 500° C., or there will be serious risk of the superheater tubes being overheated and softened. Subdivision of the superheater and taking part of the steam out to a cooling pipe in the boiler before returning it to the superheater, does protect the latter, but also introduces additional pipes, fittings, and pressure loss.

In the Kose regulator all the superheated steam is passed through a bundle of cooling tubes which is automatically submerged to a greater or less extent in the boiler water so as to maintain any desired steam temperature. If steam be passed through an independent cooling drum (fed with hot feed-water and delivering any steam raised to the main boiler), the temperature of superheat is controlled effectively and the cooler and boiler are both more accessible for cleaning, etc. In the Wedertz regulator, water from the boiler is passed through a cooling tube mounted concentrically in a late stage of the superheater. Steam raised in the cooling tube is admitted to the steam main. The superheater itself is protected by this device, but fitting the cooling tubes offers mechanical difficulties. The Steinmuller regulator by-passes part of the steam rising through the front header and uses it to blow more or less water into the steam going to the superheater. From 80 to 100 deg. C. control is obtained and the superheater does not exceed the temperature of the steam delivered. In the Germaniawerft regulator water is sprayed into the superheater tubes from a concentric water pipe which has a number of fine holes on a spiral at the base of a helical strip mounted between the two tubes and serving to ensure thorough evaporation.

In order to prevent formation of scale deposits in the superheater, Walther et Cie. use for cooling the overheated steam only pure condensate obtained by taking part of the boiler steam over a miniature surface condenser through which feed-water passes. In any case it is important that no unvaporised water particles be carried forward by the superheated steam. Temperature reduction by mixing saturated with superheated steam is practicable only where the superheat is moderate and the desired temperature decrease is small. A 8-way hand valve or an automatic valve may be employed.

R. E. N.

153. *Performance and Design of Surface Feed-water Heaters.* **M. C. Stuart.** (Am. Soc. Naval Eng., J. 29. pp. 508–524, Aug., 1917. Am. Soc. Mech. Eng., J. 89. pp. 1045–1046, Dec., 1917. Abstract.)—The author develops his theory of heat transmission from the fundamental law that transmission varies as the temperature difference. This assumption in the case of a tube with steam on one side and water on the other, leads to simple equations for the temperature-rise curve. The mean temperature-difference between water and steam, and the rate of heat-transfer from steam to water are then determined; the mean temperature-difference being defined as the

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average distance between the curves of steam and water temperature. Theoretical relations between temperature and tube length may best be tested experimentally on multi-pass heaters with temperature readings taken at the end of each pass. Data are given from tests on a 4-pass heater, and from these data a temperature diagram is plotted with the inlet temperatures of the several passes as abscissæ and the corresponding outlet temperatures as ordinates. If a diagonal "base line" be drawn, corresponding to equal inlet and outlet water temperatures, this will meet the actual inlet-outlet temperature line at the steam temperature. The outlet temperature of one pass is the inlet temperature of the next pass, so that we have a sort of "stairway" between the base line and actual temperature line. The "step" becomes smaller for each successive pass. The temperature diagram confirms the theory that the heat-transfer coefficient is independent of temperature and depends only on the ratio of initial to final temperature-difference.

The same method is extended to the case of a condenser tube, reference being made to a temperature diagram obtained by G. A. Orrok. Determination of the heat-transfer factor K under various circumstances is discussed fully in the original paper. The author gives three graphical methods for showing the relation between tube length and water temperature; also, a logarithmic chart of heat-transfer factors and friction drop. The relation between K and ft. per sec. may be expressed by $K = 339V^{0.61}$, which agrees with Orrok's and other results. The author concludes that the design of any heat-transfer apparatus consists in determining proper balance between tube length, number of tubes, velocity, total surface, friction drop, and temperature-rise. An analytical method is given for the design of feed-water heaters. This is based upon the relation between heat-transfer coefficients and velocity, $K = aV^n$; and the relation between friction loss and velocity, $H = bLV^m$. By combining these empirical equations with the theoretical equation for heat-transfer coefficient, there is obtained :—

$$V^{1-n+m} = aC_2H/\left[bc \log_e \{(t_s - t_1)/(t_s - t_0)\}\right],$$

where t_s, t_1, and t_0 = temperatures (°F.) of steam and of water at inlet and outlet respectively. R. E. N.

154. *Effects of Coal-storage upon Properties and Value.* **S. W. Parr.** (Univ. of Illinois, Eng. Exp. Sta. Bull. No. 97. [89 pp.], May, 1917.)—The conclusions arrived at by the author as the result of his investigations are as follows: (1) Bituminous coal can be stocked without appreciable loss of heat values, provided the temperature is not allowed to rise above 180° F. In fact there is no appreciable evolution of CO_2 at temperatures below 260° F. (2) The indicated heat loss per lb. of coal is due more largely to an increase in weight of a unit mass of coal, resulting from the absorption of oxygen, than to an actual deterioration or loss of heat units. (3) Freshly-mined coal has a large capacity for absorbing oxygen, which combines chemically with both the organic combustible and the iron pyrites present. (4) The combination of oxygen with coal at ordinary temperatures generates a small increment of heat. (5) The rapidity with which oxygen is absorbed depends upon the temperature of the mass, and upon the extent of the superficial area exposed; that is, upon the fineness of division of the coal. (6) If heat be generated by this slow process of oxidation more rapidly than it is lost by radiation, the acceleration of the reaction causes a rise in temperature which quickly brings the mass up to the danger-point. A temperature of 180° F. is named as the danger-point, because if the coal reaches that tem-

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perature, practically all the free moisture is vaporised, and the further rise in temperature will be very rapid. (7) Any method of storage to be successful must either check or prevent the absorption of oxygen to such an extent that the generation of heat shall not proceed so rapidly as to exceed natural heat losses due to radiation. (8) Underwater storage prevents loss of heat values, and is not accompanied by deterioration in physical properties, such as slacking. (9) Dry storage is far more safely undertaken if the fine material is screened out at the storage-yard, and the lump only, preferably sized, is stocked. J. B. C. K.

GAS, OIL, AND WATER ENGINES.

155. *The New Bailey Commercial Wagon.* (Automotor J. 23. pp. 25–26, Jan. 11, 1918.)—This wagon is made by the Bailey Non-Stall Differential Co., of Chicago, and has a 6-cylinder motor with 5¾ in. bore and 7 in. stroke developing 180 h.p. at 1000 r.p.m. It is fitted with the Bailey non-skid differential having band brakes on either side of the casing, their function being to release the outer side and its wheel, and hold the inner side and its wheel when a sharp turn is made round a corner. A side elevation and a longitudinal section of the gear are included in the original paper. The original Bailey gear (Brit. Pats. 18,829 of 1913 and 17,680 of 1914) comprises a double free-wheel roller clutch, specially made to act for both directions of rotation, each wheel being connected to the driving shaft through one of such clutches. In the improved gear, the drive is through a central casing, like that of an ordinary differential gear, and each of the driving road-wheels has on its shaft a ratchet-wheel for engaging the clutch-rollers. The rollers of the oppositely arranged clutches are made tubular, and each two corresponding rollers of the two clutches are combined to form a pair with a toggle, which is arranged between them, and which forces apart steel balls working in spherical seats in the rollers. These balls, acting through the rollers, force apart flat rings against the inner sides of the central casing, and so drive both wheels. The clutches are disengaged by releasing plates with cam ramps for lifting the clutch rollers out of seatings in the ratchets. The release plates also control the band brakes, whereby the inner driving wheel is held when the vehicle is turning. The description and drawings in the original paper are not such as to render the construction absolutely clear. C. A.

156. *Water-power in Great Britain.* **A. Newlands.** (Soc. Arts, J. 66. pp. 168–186; Disc., 186–188, Jan. 25, 1918. El. Rev. 82. pp. 125–127; Disc., 127–128, Feb. 8, 1918. Abstract.)—Gives approximate estimates of the amount of power available from waterfalls in Great Britain. Areas having 50 in. rainfall, or over, are tabulated :—

	Total Area, Sq. Miles.	50-in. Area.	Percentage of Total Area.	Location.
Scotland	27,413	11,575	42	Highlands and Southern Uplands
England	50,058	3360	6·7	Lake and Shap Districts, Devon, and Cornwall
Wales	7876	3390	46	Central Area
Ireland.....	32,694	5910	18	Donegal, Connemara, and Killarney

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Assuming 42 in. average rainfall, with 2/3 of this (*i.e.* 28 in.) available for power, figures on a map show the power available at various places in Scotland. The flow for 24 hours is supposed to be used in 12 hours, with machinery efficiency at 75 %. The powers make a total of 875,000 h.p., but by diversion and linking up adjoining catchment areas and further impounding 650,000 h.p. may be available for 100 days' supply. The largest installation is that of the British Aluminium Co. at Kinlochleven [Abs. 786 (1912)] ; 20,000 million galls. of water are impounded to give 80,000 h.p. for 100 days, at a cost of £600,000. The output is 150,000,000 units per annum ; after allowing for interest and depreciation the cost of energy is 0·0625d. per unit with load factor nearly unity. The same company has 7000 h.p. installed at Foyers. At Raven's, near Strathpeffer, 120 h.p. is developed from a dam costing little more than an ordinary farm mill-dam, with a head of 600 ft. If the powers available are regarded as a national asset, they should be developed to a maximum efficiency under statutory control to ensure the same periodicity of current at every power station for feeding into a network of transmission lines. The Ministry of Reconstruction recommend 16 stations normally 20,000 h.p. each.

The advantage of combining industry with agriculture is considered. Numerous minerals occur in many parts of Scotland, *e.g.* pegmatite, graphite, molybdenite, chromite, steatite, diatomite, etc. An approximate formula for horse-power obtainable in a given area is: h.p. = AH 18, where A = catchment area, in sq. miles, and H = fall utilised in feet.

W. N. Y. K.

157. *Problems in Aeronautics.* **A. G. Webster, G. O. Squier, W. F. Durand, W. R. Blair, E. B. Wilson, J. C. Hunsaker, L. A. Bauer.** (Am. Phil. Soc., Proc. 56. pp. 161–257, 1917.)—The dynamical principles underlying the theory of flight are outlined in the first part of the paper by **A. G. Webster**, while **G. O. Squier** points out the importance of the atmosphere and the different problems underlying its various actions and movements. **W. F. Durand** deals with the mechanical problems presented by the heavier-than-air machine as regards (i) structure of aeroplane, (ii) power-plant, (iii) propulsion. He concludes that the chief demands, on the realisation of which future progress must depend, are the following: (*a*) Minimum weight of structure in relation to area of supporting surfaces, and of power plant per unit of power developed. This will secure increased carrying capacity for fuel and supplies and for useful weight such as passengers, mail, etc., and will serve as a factor in either long life in the air or heavy carrying capacity for short distance. On the other hand, such extra weight-carrying capacity may be put into additional power plant, engine and fuel for correspondingly increased speed over shorter distances. (*b*) Maximum economy of prime mover and in applying its power for propulsive purposes. This will ensure minimum consumption of fuel and supplies per unit of time or distance, and hence will serve as a factor in long life in the air or in large weight-carrying capacity, or in added capacity of prime mover with corresponding increase of speed for shorter distances. (*c*) Reliability of operation. This embodies improved methods of control and navigation, and greater reliability in each of the many individual elements on which overall reliability depends. These improvements are of special significance in the problem of lengthening the effective life in the air and, broadly, in the extension of the usefulness of the aeroplane, especially in the arts of peace.

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W. R. Blair, in an account of the importance to aeronautics of aerological observations, gives a general survey of the results obtained by observations of the movements of the upper air, and shows diagrams of the means of wind observations over the years 1905–1912 at heights of 526, 1000, 2000, 3000, 4000, 5000 m. He also quotes tables showing (i) the relative frequency of winds from the different directions observed at each level, and (ii) the mean velocity of winds from each quarter at each level. At the 5000-m. level all the observed winds lie between WSW. and NNW. The diurnal variations in the temperatures at different heights above Mount Weather Observatory are also discussed. **E. B. Wilson** continues a previous investigation of the problem of an aeroplane encountering a periodic gust [see Abs. 415 (1917). For the particular form of machine considered (the Curtiss Tractor JN2) he finds that for periodic longitudinal gusts, even in the case of best resonance with the slow natural oscillation, the motion is not much different from that produced by a simple head-on gust until after a considerable time (over 14 secs.) has elapsed. The amplitude of the forced oscillation (in up-and-down motion) which ultimately becomes effective is about 5 times the amplitude of the gust. This is not regarded as serious, because true periodicity can rarely be maintained in a head-gust and because no pilot would wait to let its effect reach such a magnitude. Periodic up-gusts and rotary gusts are considered as not likely to arise. For lateral gusts the following conclusions are reached: (*a*) Single side-gusts are shown to produce moderate side-slipping, insignificant roll, and moderate yaw. It is shown that the yaw is into the relative wind, so that the displacement of the machine in space is towards the gust despite the slide-slipping. (*b*) Oscillatory side-gusts are shown to be a common condition of flight, to produce moderate side-slipping and yawing, but insignificant rolling. The path of the centre of gravity is sinusoidal, so far as the forced oscillation is concerned, and of amplitude about 2 or 3 times the amplitude of the gust. (*c*) Yawing gusts are found to induce a good deal of side-slipping, but do not appear to be serious. The roll is very small. (*d*) Rolling gusts are shown to put the machine into a spiral dive, and thus to cause a real danger unless the motion is checked promptly by the pilot. It is concluded, finally, that a device to keep the aeroplane on its course or to prevent rolling makes the previously unstable machine stable. Such a device might be important to reduce the liability to the spiral dive in rolling gusts, provided such gusts were common phenomena in flying weather. **J. C. Hunsaker** discusses the special problems attached to the design of a lighter-than-air machine, including the changes in buoyancy due to expansion and contraction of the gas under change of temperature, the accumulation of moisture or sleet on the fabric with consequent increase of weight, gas leakage through the envelope, the change of electrostatic potential with change of height, the problems involved in structural design and the difficulty of calculating the various stresses which come into play. **L. A. Bauer** concludes with a description of the peculiar difficulties attending the use of a magnetic compass on an aeroplane.

J. W. T. W.

158. *Propeller Computer for Aeroplanes.* **W. P. Loo.** (Frank. Inst., J. 184. pp. 901–906, Dec., 1917.)—Gives a description of Zahm's apparatus for the mechanical calculation of the thrust and torque of a propeller of known elements and of determined lift and drift coefficients. For a description of the theory and method of use of the apparatus the original paper should be consulted.

J. W. T. W.

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PROPERTIES OF ENGINEERING MATERIALS.

159. *Cylinders for dissolved Acetylene.* (Report of Home Office Departmental Committee, 1918 [28 pp.]. Engineering, 105. p. 155, Feb. 8; *erratum*, p. 285, Feb. 22, 1918. Abstract. Engineer, 125. pp. 125–126, Feb. 8, 1918.)—Acetylene may explode under pressure, even when pure. The Order in Council of 1897 limited the pressure in acetylene cylinders to 100 in. of water; in 1914 the limit was raised to 250 in. In 1912 the use of porous material in such cylinders was legalised; such materials dissolve many times their volume of acetylene with or without the addition of a solvent like acetone. Several accidents having occurred in England with cylinders of "dissolved" acetylene, a Committee was appointed in 1916, and experiments were made at Eskmeals and at the National Physical Laboratory. The cylinders that failed were all of 200 cub. ft. capacity and their covers and bottoms had been welded by the oxy-acetylene process; the failures were due to the welding, it is found. Three kinds of porous materials are in use: (1) an agglomerate of asbestos, kieselguhr, charcoal, and some cement—a good mixture, but heavy, and difficult to fill in and remove; (2) charcoal—light, easy to fill in and remove; (3) kapok—very light, not so easy to remove as charcoal. The porosity of these materials in the cylinders, it is recommended, should not exceed 80 %, and pockets formed by caving-in of the material be avoided, though fuses placed inside gas pockets and detonators breaking the cylinders from outside did not give rise to general explosions. Instead of acetone, two substitutes known as carbitone and calcitone (early distillation products of the acetone manufacture) are used as solvents, alone or mixed with acetone. The report would not interfere with their use up to 40 % of the cylinder volume, provided each solvent be kept separate. The gas pressure may be raised to 225 lbs. per sq. in. at 60° F., but only in solid-drawn cylinders in which flanges hold the top and bottom, so that the strength does not depend merely upon the weld. The cylinder material should be a mild steel of 0·25 % C, containing not more than 0·05 % of S and of P. The cylinders should be tested at four times the working pressure for at least 15 minutes and be annealed. The use of safety plugs, which may prove a source of weakness, is not recommended. Retesting might be confined to external inspection, since internal corrosion was not observed; other recommendations are made also as to the refilling of cylinders. The use of oxy-acetylene-welded cylinders is deprecated, and they should be withdrawn so soon as circumstances will permit. H. B.

160. *Dezincification of Brass Pipe.* **E. B. Story.** (Met. and Chem. Eng. 17. pp. 653–655, Dec. 1, 1917.)—Shows how brass used commercially for water systems changes into a weak and brittle form which readily cracks and fails under slight stresses. Brass pipe which has undergone this change is invariably accompanied by a greyish-white deposit. When this deposit is removed and the brass is scraped, the underlying metal appears much redder in colour. This change is termed "dezincification." Analysis of dezincified particles of brass pipe and photomicrographs of brass undergoing dezincifica-

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tion are given and it is stated that the slightest cause, such as segregation, slight stresses, etc., which may seem remote and of little consequence, are sufficient to produce the nucleus of deposited copper and start the action which ultimately results in the failure of the brass pipe. C. O. B.

161. *The Testing of Refractory Materials.* **J. W. Mellor.** (Engineering, 104. pp. 382–383, Oct. 12, 1917. Paper read before the Ceramic Society, Glasgow, Oct., 1917.)—Referring to his communication of 1909 to the Society, the author pleads for standardisation. The softening temperature of a refractory is varied by rapid heating. It is generally determined on specimens, of conical or prismatic shape, 1½ in. high, ¼ to ¾ in. base, alongside a number of Seger cones covering a wide range of temperature. As there is no definite melting-point, this primitive method is preferable to temperature determination by pyrometers, etc.; and since fusion begins at the surface, owing to surface tension, larger specimens would not offer advantages. Standard tests under load are difficult; the results should be expressed in curves. Spring and also Tresca had melted alumina at ordinary temperature under high pressure, and W. H. Turner made vitreous pottery under enormous pressure without firing; those experiments should certainly be repeated. Bricks are usually fired in an oxidising atmosphere; they should be tested in a reducing atmosphere, however, in which they are mostly used, though the reduction of iron is very slow. Since thermodynamically $dT/dp = T(v - v_0)/L$, where v and v_0 are the volumes after and before fusion, and since fireclay expands by about 6 % on fusing, an increase in pressure should raise the fusion temperature; actually, however, it lowers this temperature. The apparent discrepancy is explained by the fact that the formula is not really applicable, because theoretically the pressure is assumed to be uniformly exerted in all directions, whilst the interstices between the grains of a firebrick would give the pressure the character of a shearing stress. Making use of Roozeboom's vapour-pressure curves of the solid and the liquid states, the author shows that the solid and liquid phases do not suffer the same increase in pressure; when the solid alone is subjected to the pressure, the resulting lowering of the melting-point can be calculated from Riecke's formula.

H. B.

162. *Gas Furnace for Testing Refractory Materials under Load.* **R. J. Montgomery.** (Met. and Chem. Eng. 18. pp. 18–20, Jan. 1, 1918.)—A brief but illustrated description is given of a cylindrical brick furnace used in the laboratories of the H. Koppers Co. and the Pittsburg By-Product Coke Co. The outer dimensions of the brick furnace are: diam. 40 in., and height 84 in. The two burners fed with gas and compressed air are placed tangentially inside the furnace so as to give a whirling flame; the draught is downward through the furnace bottom. Two specimen bricks are tested simultaneously; they are placed on edge, and each is covered while under pressure by a cup of highly refractory material, which will not stand many tests, however. The cups are attached to the two vertical rods through which the pressure is applied from a weighted balance beam above the furnace; the rods pass through the top of the furnace. Tests at a pressure of 100 lbs. per sq. in. and 1500° C. are mentioned, but results are not given. H. B.

163. *Fabrication of Silica Bricks.* **H. le Chatelier and B. Bogitch.** (Comptes Rendus, 165. pp. 742–748, Nov. 26, 1917.)—Experiments, partly

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made at three different works, show that silica bricks should contain some coarse particles to prevent the spreading of cracks; these particles should, however, not be larger than 5 mm. On the other hand, a certain percentage of impalpable quartzite powder is necessary to form the magma [the continuous *réseau*, see Abs. 767 (1917)], since particles of more than 0·01 mm. are not dissolved during the burning. The materials for the experiments were slime from gold mines, washed with acid, crushed quartzite of 4 mm. maximum, and 2 % of lime; the bricks were burned at 1400° and 1450° and tested cold and hot at 1600°. The best results were obtained with 25 % of impalpable quartz and 75 % of coarser quartzite; with 75 % of slime the bricks tended to develop cracks. When the bricks, instead of being made by hand were compressed (200 kg./cm.²), the cold strength was raised, the hot strength hardly affected; coarse quartz from old bricks gave slightly lower, but still satisfactory results; no advantage was gained by its use. The substitution of 6 % of clay (highly fusible) in the place of the 2 % of lime reduced the strength a little further, but the mixture of 75 % of crude quartzite, 25 impalpable powder and 6 clay gave bricks, which did not break suddenly, as in the other cases, but yielded progressively. Attention is drawn to this point. H. B.

164. *Manufacture of Silica Bricks.* **Philippon.** (Comptes Rendus, 165. pp. 1002–1005, Dec. 17, 1917.)—Experiments were conducted in 1916 and 1917, at the Usine des Dunes, with quartz from four sources, mixed with milk of lime (2 % mostly) for 10 minutes, the bricks being made by hand in each case out of 200 kg. of material, dried at 100°, and burned at 1800°; fusion tests of cut-up bricks were conducted in acetylene furnaces. The conclusions are very similar to those of H. le Chatelier [see preceding Abs.]. The strength increased with the fineness of grain; impalpable quartzite powder gave strengths of 18 and 320 kg./cm.² dry and baked, whilst sifted grains of 0·18 mm. gave only 2 and 16 kg.; the further addition of water and of lime (up to 2·5 %) also increased the strength; the swelling of the baked bricks increased with the coarseness of grain, the bricks of impalpable powder practically did not swell. When impalpable powder was used, a strength of 190 kg./cm.² was already reached at 800°, and a strength of 270 kg. at 1800°; grains of 0·18 mm. did not begin to harden below 1100°, and at 1800° the strength was only 70 kg. On the other hand, the bricks with a minimum of impalpable powder proved the least fusible; 8 mm. seems to be the maximum advisable grain size. In their ordinary practice the works now use 30 % of impalpable powder and 70 of coarse grains (1 to 8 mm.) mixed with 0·6 % of lime; these bricks have a density of 2·4 (apparent density 1·9), swell by 1·6 %, and have a strength of 200 to 250 kg., fusing at 1780°; they had already borne more than 200 heats in Martin furnaces. H. B.

165. *Easy Way of Figuring Radiation.* **K. Toensfeldt.** (Power, 46. pp. 726–731, Nov. 27, 1917.)—The author presents a series of charts facilitating calculation of steam radiator surface required by a room with 18-, 18-, or 22-in. brick walls. Other charts are provided for glass surface and air leakage. The sum of readings from three charts gives the total radiation to be provided. The wall area (including all windows) is first considered as wall; to the heat loss thus calculated is added the loss by which the window exceeds the wall. The formulæ on which the charts are based are:—*Brick walls.*—$H_w = Ak_w$ and $R_w = 70Ak_w/260$; where H_w = B.Th.U. per hr. per 1 deg. F.

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temperature-difference; A = area of walls, including windows, in sq. ft.; k_w = unit heat loss for the wall; R = sq. ft. direct radiation for 70 deg. F. temperature difference; 70 = temperature difference between outside and room, in. deg. F.; 260 = B.Th.U. per sq. ft. of radiator surface, with steam at atmospheric pressure and room at 70° F. *Glass in walls.*—$H_g = A(k_g - k_w)$ and $R_g = 70A(k_g - k_w)/260$; where k_g = unit heat loss for glass = 1 B.Th.U. per sq. ft. per hr. per 1 deg. F. temperature-difference. *Air leakage.*—$H_a = C/56$ and $R_a = 70C/56 \times 260$; where C = cubic contents of room (determined as below), and 56 = cub. ft. of air raised 1 deg. F. by 1 B.Th.U.

A second scale on the wall and glass charts allows 10% extra radiation in the case of north and west walls subject to exposure. In allowing for air leakage, the rule may be one air-change per hour. Special allowance should be made in special cases, but one change per hour in a room as deep as it is high, is good practice. If the total lineal ft. of exposed wall be multiplied by the (height)^2 and the product be assumed as the air change per hour, the approximation is reasonably good for deep and shallow rooms alike. The charts cover the usual run of building materials, are easy to use, and can be used for hot-water systems if the ratio of heat dissipation between steam and hot-water radiators be applied. R. E. N.

166. *Heat-transfer from Air to Pipes.* **C. H. Herter.** (Am. Soc. Refrigerating Eng., J. 4. pp. 808–832, Nov., 1917. Am. Soc. Mech. Eng., J. 40. pp. 115–116, Jan., 1918. Abstract.)—The author cites references showing that the value of k given by various authorities ranges from 18 to 1 B.Th.U. per hr. per sq. ft. of air contact surface with pipe, per 1 deg. F. mean temperature difference between air and surface. Seibel (1916) states that German engineers take k to be 1·2 to 1·7 B.Th.U. for air through metal to air, and 2·15 to 3·15 for water through metal to air; he also estimates R = 10 B.Th.U. for ammonia vapour through iron coils to air, but the author considers this value to be inconsistent and improbable. The author also considers that 520 to 600 ft. of 1¼-in. pipe should be allowed per ton refrigeration, instead of half this allowance as recommended by Seibel. Leonard's 1904 tests with iron pipes filled with hot water and exposed in vertical position to air outdoors in the shade, yield $k = 1{\cdot}894$ to 3·55 B.Th.U. for various pipe sizes and various air temperatures; the latter value is for pipe exposed to wind blowing 480–720 ft./min. Tests by the Armstrong Cork Co. gave values of k from 1·8 to 2·18 B.Th.U.

A set of curves is given, showing values of k in B.Th.U. per hr. per sq. ft. per 1 deg. F. temperature-difference as a function of air velocity v, in ft. per min. Buffalo tests with steam-jacketed air tube, longitudinal flow of air, yield $k = 1/[0{\cdot}026 + (187/v)]$. Lorenz and Heinel's tests for brine pipes to air with forced air circulation and velocities exceeding 200 ft./min., yield $k = 0{\cdot}41 + 0{\cdot}1458\sqrt{(v)}$. For dry direct expansion pipes, the same authorities give $k = 1{\cdot}888[0{\cdot}41 + 0{\cdot}1458\sqrt{(v)}]$. For wetted direct expansion pipes and for wetted flat surfaces, $k = 0{\cdot}41 + 0{\cdot}2626\sqrt{(v)}$. Buffalo tests with standard 4-row indirect or coil-pipe heaters, consisting of 1-in. pipes placed on 2⅛-in. centres, air flowing transversely through the heater, give $k = 1/[0{\cdot}0447 + (50{\cdot}66)/(v)]$, where v = air velocity in ft./min. through clear area of heater. The latter tests show that up to 1200 ft./min., k varies approximately with the two-thirds power of the velocity, and not with the square root of velocity as has often been stated.

The author gives a simple equation for k in the case of heat-flow from one medium to another through metal walls of a pipe; and an equation for a pipe

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covered with paint or ice on its outer surface and with congealed oil or grease inside.

Other points made by the author and during the discussion are as follows :—Since all the factors of heat-transfer are variable, the best thing is to secure an approximate figure covering maximum and minimum conditions in refrigerating plants. It is sound practice in refrigerating work to have surplus cooling and condensing surface, otherwise high pressure is often needed to condense a given unit of gas and high efficiency cannot be maintained under commercial fluctuations. Reference is made to Wood and Fehr's determinations of temperature gradients. The heat emitted by a pipe is independent of conditions prevailing inside the pipe, so long as the surface temperature is the same for different cases. Gradients for a glass-fronted test-box show that air films offer the principal resistance ; the glass offers a very small part of the total resistance. Moving air causes marked change in the temperature gradients.

R. E. N.

167. *On Water-hammer.* I. *Calculation of the Pressures exerted at any point whatever along the pipe.* **C. Camichel, D. Eydoux,** and **M. Gariel.** (Comptes Rendus, 165. pp. 626–629, Nov. 5, 1917.)—The authors first deal with pressure variations in the neighbourhood of the distributor, and verify that the pressures produced in the pipe by a rapid or slow closure may be calculated exactly from the formulæ of Allievi and de Sparre. For finding the apparent period of the pipe it is necessary to use de Sparre's formula relating to pipes subdivided into 2 or 3 sections ; the latter formula has been verified experimentally by the authors. The same formulæ are applicable when openings are made. The limiting case when the water-hammer is independent of the speed is dealt with.

The second section of the paper contains an investigation of the transmission of water-hammer along the pipe ; three cases are dealt with, namely : integral transmission where the pipe has a characteristic constant ; linear distribution produced in pipes furnished with air-pockets ; and sinusoidal distribution, where it is shown that when the pressure curve at the distributor takes a sinuosidal form the pressure and speed along the pipe have a sinuoidal distribution.

The third section deals with the influence of loss of charge, and the fourth with resonance. Details of an experiment are given to show the importance of the apparent period and of its resonance. [Abs. 20 (1918) should also be consulted.]

H. H. Ho.

168. *Substitutional Tyring for Passenger Automobiles.* **A. Heller.** (Zeits. Vereines Deutsch. Ing. 61. pp. 879–881, Oct. 27, 1917.)—During the last year various substitutes have been devised for pneumatic tyres on passenger automobiles ; these substitutes being practicable under war conditions, though not entirely satisfactory. The decree of December 18, 1916, relaxed the law restricting the speed of vehicles with other than rubber or similar elastic tyres to 25 km. per hr. The decree of April 24, 1917, recognised six patterns of substitutional tyring as permissible until further notice.

Substitutes for pneumatic tyres fall into two classes :—(1) Those with a rigid rim of metal or wood capable of moving only in the direction of the spokes. (2) Those in which "spoke springing" is supplemented by a species of "rim springing," *i.e.* a flexible outer rim in addition to springs between the two rims. Typical examples of both types of tyres are given in the original.

The Arop wheel is simple and effective. A single or a double row of

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spiral springs wound from square steel is carried by dowelled spring plates or mountings between an inner and outer rim; but this arrangement is not suitable for high-speed vehicles because the springs are not secure against displacement by lateral forces when running round curves or over obstacles. This risk is eliminated in the Moll wheel by placing each spring between two end-caps which are spherical on their outside, and provided with tubular extensions down the inside of the spring. One of these extensions slides within the other, forming a telescopic combination which prevents lateral displacement of the spring, whilst the spherical ends permit lateral displacement of the rim.

The special advantage of the Fruth wheel, built by the Maschinenfabrik Augsburg-Nürnberg is that the springs are protected against bending or displacement by the peripheral force accelerating or retarding the vehicle, Oval springs are placed between the inner and outer rim on their sides, so that the wheel pressure comes in the plane of the winding. Successive springs are overlapped (going circumferentially round the wheel), and cross-bolts pass through the overlapping loops. The springs lie in two U-troughs which fit one within the other and relieve the springs from all transverse forces. The outer rim and the complete spring system can be mounted as one piece on the inner rim as substitute for a rubber tyre. Replacement of broken springs is not easy.

The Sievert wheel uses a composite wooden rim (part of its timber being cross-cut) with steel side rings, between which and the sides of the inner rim are rings of rubber or other elastic material. The whole load is transmitted through the rubber side rings; these have a long life, since they are protected by the side plates. Wear comes on the wooden road rim.

The Siemens and Halske wheel uses spiral springs mounted radially between cups attached to the inner and outer rims. In addition, the outer rims consists of continuously wound strip steel secured by cross clamps at intervals and protected by leather or similar material which is riveted on and renewed as required. The springs are inadequately protected against dirt and against transverse forces, but the elastic rim improves the smooth running of the wheel and reduces the risk of side-slip. The Flohr wheel is of similar construction, but the outer rim is built up on the same principle as a link belt. The link-pins serve as supports for the spring cups on the outer rim, but they are not protected against dirt and water. R. E. N.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

169. *Carbon as a Catalytic Depolariser in Primary Cells.* **C. Féry.** (Soc. Int. Élect., Bull. 8. pp. 7–11, Jan., 1918.)—The author has continued his work on primary cells [Abs. 424 (1917)], and describes experiments showing the extent to which carbon is capable of acting as a depolariser in cells consisting of carbon and zinc in a solution of ammonium chloride. The results obtained depend considerably upon the quality of the carbon used. It is stated that impure ammonium chloride containing traces of lead and iron completely poison the carbon for such a purpose. Similarly the carbon must not contain certain metals forming gelatinous hydroxides. Curves are given showing the results obtained. The cells gave constant currents of about 20 to 50 milliamps. at varying voltages over periods of 4 to 2 months respectively, with high efficiency. The size of the cells is not stated. W. R. C.

170. *Electrolytic Pickling of Steel.* **M. De K. Thompson** and **F. W. Dodson.** (Met. and Chem. Eng. 17. pp. 713–714, Dec. 15, 1917.)—Experiments are described which were carried out by the American Sheet and Tin Plate Co., comparing electrolytic pickling with ordinary chemical pickling. Acid was generally used, and in one case consisted of 85 % by weight of sulphuric, with 2 % hydrofluoric acid. The tests did not show any very striking advantage of the electrolytic over the chemical pickling so far as the amount of acid used is concerned. Probably the electrolytic methods show to greater advantage as the scale becomes thicker. The presence of ferrous sulphate does not appear to play any part. W. R. C.

171. *Development of the Côte-Pierron Electric Zinc-smelting Process.* **G. Flusin.** (Bull. Techn. de la Suisse Romande, 43. p. 288, Nov. 17, 1917. Met. and Chem. Eng. 18. p. 17, Jan. 1, 1918.)—A plant of 4 furnaces, of 500 h.p. each for a capacity of 4 metric tons of ore per 24 hours, was to be opened at Maurienne, near Epierre. The ore, blende (and galena), is not roasted; it is mixed with lime and carbon and passed into the compound furnace, a combination of an arc-resistance and an indirect-resistance furnace. In the former the ore is smelted and partly vaporised; the metallic dust and droplets are at once redistilled in the latter furnace and condensed as liquid metal of 99·98 % Zn. The total loss ranges from 6 up to 9 %; the electrode consumption is 12 kg. per ton of ore; there are no further particulars.

H. B.

172. *Electrical Stimulation of Crops.* **L. Birks** and **O'D. Davis.** (Journ. of Agriculture, N.Z. pp. 185–190, Oct., 1917.)—Having referred to the work of Jorgensen and Dudgeon [Abs. 894 (1916)], the authors describe two experimental installations in the Canterbury district of New Zealand. In both cases electric lamps are used for keeping the frost out, the lamps being turned on overnight; the remarks on other applications of electricity are general. In the first case 15 nitrogen-filled 100-c.p. lamps were suspended 2 ft. above ground in a glass-house for tomatoes; the house was also steam-heated, but the steam-heating broke down and was then discontinued; the yield was increased. In the second case a 250-watt radiator lamp was suspended in the centre of each of the trees of an orchard; the apples profited, the pears did not.

H. B.

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173. *The Utilisation of Manganese Ores in Sweden.* **J. Harden.** (Electrician, 80. pp. 611–612, Jan. 25, 1918. Abstract of paper read before the Meeting of Chemists in Sweden, June, 1917.)—A good deal of ferromanganese is still produced in blast furnaces, but by this method the loss of Mn is very high, owing to the metal and its compounds being volatile at high temperatures, and a good deal of reoxidation is unavoidable. For these reasons the electric smelting method has come into use, more particularly in countries like Sweden, where the supply of ore is rather limited, and charcoal is becoming more and more expensive. Another reason is that the material produced in the blast furnace always has a very high percentage of carbon, as a rule from 8 to 12 %. If this high percentage is cut down the losses are prohibitive. The electric furnaces used are single-phase and three-phase, but the latter are generally favoured. The furnace is charged with the proper mixture of ore, coal and flux, and iron is added as required, the iron being in the form of scrap. In the case of a furnace of, say, 3000 kw. the consumption of energy should not be more than 8000 to 8500 kw.-hrs. per ton of ferromanganese.

With regard to using the alloy, the best method is to use it in the liquid state, adding it at the right moment directly to the liquid steel in the ladle. The electric furnace is very suitable for the purpose of heating up the alloy. The author gives experimental figures showing the thermal efficiency as 43·4 % for an arc furnace and 68·2 % for an induction furnace. The cost of operating an arc furnace for this purpose is as follows :—

Cost per Ton of Ferromanganese.

Power : 888 kw.-hrs. at 0·02s. per kw.-hr.	16·66 shillings
Electrodes at 85s. per 100 kg.....	1·90
Labour costs	1·65
Linings and repairs	0·65
	20·86

The corresponding figure for an induction furnace amounts to 19s. 3d. per ton, the cost of power in each case being approximately 0·24d. per kw.-hour. The loss in Mn in both cases was very slight, viz. 0·385 % in the electrode furnace and 0·360 % in the induction furnace. Comparative tests show a saving of 44·3 % in ferromanganese, added in a liquid form, as compared with using the solid pre-heated in an oven. The author expresses the opinion that the electric furnace has one of its largest fields in this direction at present, as no other furnace is so adaptable to the work. W. R. C.

174. *Insulating Materials.* **Bültemann.** (Elektrot. u. Maschinenbau, 35. pp. 575–581, Dec. 2, and pp. 588–592, Dec. 9, 1917. Paper read before the Elektrot. Verein, Dresden, July, 1917.)—This is an examination of the physical and electrical properties of different insulating materials. These include glass, marble, slate, porcelain, and other substances that have long been used for the purpose : but the main interest is connected with the newer materials which are sold under various trade-names. For the purposes of this abstract the names of a few of these materials may be given, and for details the original paper should be consulted. Information is given about galalith, pertinax, presspahn, vulcanised fibre, celluloid, cellulose acetate, bakelite, faturan, eswelite, etc. In the cases of some of these, various processes of manufacture are outlined, particularly in the matter of cellulose acetate (also called cellon), and bakelite. The final section of the paper deals

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with insulating oils and their properties. The whole contains a good general survey of the ground connected with the manufacture and properties of insulators. W. H. S.

175. *Factors affecting the Selection of Insulators.* **A. O. Austin.** (El. World, 70. pp. 1284–1286, Dec. 29, 1917.)—The cost of insulators is often less than 8 % or 4 % of that of the rest of a transmission system, and in most cases better insulation would be a sound investment. Liability to interrupted service depends on the size of system; insulators are strained more by steel towers than by wooden poles; competition and the nature of load supplied influence the margin of safety to be provided in insulators. The author here considers the advantages and disadvantages of ground wires, the effects of switching surges on insulators, the relative merits of independent and parallel circuit operation, and the effect of local conditions.

The advantages of ground wires are often doubtful and are offset by the troubles introduced. A ground wire on a steel structure does not much increase the risk of short-circuits due to birds and may protect the insulator, but the investment represented had better be applied to extra insulation. On a wood-pole line, a ground wire protects the poles but increases the strain on insulators and gives more short-circuits from birds, and more flash-overs and punctures (especially if steel cross-arms be used, tied to the ground wire). Even the largest pin-insulators can hardly prevent kick-outs from lightning when used on a grounded cross-arm, because a flash-over strength exceeding 800 kv. would be required. Eliminating the ground wire and using a small wire down each pole will protect wooden poles; and ground resistance will prevent many "spills" from becoming short-circuits. If the wire be insulated from the poles it is still more effective. Much larger insulators are required to give the same reliability with guyed structures as with wooden poles. Unless guys are insulated thoroughly they may remove in one way as much security as they add in another.

The mechanical advantages of strain insulators must be very pronounced to justify the increased electrical hazard compared with suspension insulators. In the larger insulators, the hazard increases from 30 to 60 times that for suspension insulators, owing to matching of defects.

Switching surges may cause much trouble where a number of faulty components in the line insulation are "matched." The voltage-rise may be relatively small; it is the high-frequency oscillations which cause the damage by producing overheating in air-pockets or internal defects with a partial vacuum. The risk is particularly great in depreciated multi-part insulators because failure of one part throws extra stress on the others. Less insulation may be used safely where there are no switching surges. Switches which insert resistance or reactance before opening are very valuable. If it is difficult to restore or maintain service after interruption the voltage should be built up gradually. Low charging current in insulators lessens the shunting of defective parts, hence insulators with low electrostatic capacity or mounted on wooden structures have lower secondary hazard. Resistances should be placed in series with arresters or other apparatus liable to induce high-frequency disturbances. As regards the total system hazard, switch surges are more to be feared than lightning.

Automatic relays may maintain practically continuous service where two lines serve a load, though there may be many interruptions on either circuit. With high secondary hazard it is better to operate the lines independently. Up to 150 miles the parallel circuit has far more disturbances

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than the single line, but power is off for less time. For greater mileage the single circuit is better in both respects and would give far better service than the parallel circuits, even when tied together and operated with automatic relays.

As regards local conditions, altitude may be neglected (unless extreme) because clear air, low temperature, low stresses, and greater dielectric factor of safety more than compensate the reduced flash-over. Conditions near cities are more and more severe; better insulators rather than larger ones are required, and the insulator should be made up of parts with low surface stress. At points difficult of access or offering special risk, more suspension insulators should be used or larger or better insulators should be employed. Generally, better insulators with fewer parts are the best compromise. The more cement surface in an insulator, the more uneven the heating and the greater the mechanical stresses. In pin-type insulators with many parts the rate of depreciation must be very low or a prohibitive number of insulators will have to be scrapped to weed out relatively few defective parts. The cost of a pin-type insulator increases rapidly with size, but so does the total tested strength of the parts. R. E. N.

176. *Method of measuring Power-factor on Three-phase Circuits.* **E. G. Barrington.** (El. World, 71. pp. 140–141, Jan. 19, 1918.)—The power-factor on 3-phase circuits may be obtained by wattmeter readings, both for balanced and unbalanced loads. The method is based on the consideration that, if I be a current and E′ and E″ any two voltages at a phase difference θ and the angle ϕ between I and E′ is required, then

$$\tan \phi = \{[(OB/\cos \theta) - OA] \tan (90 - \theta)\}/OA,$$

where OA and OB are the components of the current I in phase with the voltages E′ and E″ respectively. OA and OB may be determined from the readings of a wattmeter carrying the current I in its series coil and having its potential coil connected in turn across the voltages E′ and E″. If these readings are R′ and R″, then $OA = R'/E'$ and $OB = R''/E''$. In the 3-phase case a polyphase wattmeter would normally be connected with its current coils carrying the currents C and A and the corresponding voltage coils across the lines BC and AB. By reversing the voltages AB and CA and connecting them, instead of the voltages BC and AB across the coils in question a reading proportional to the components of the currents C and A in phase with voltages lagging 60° behind the voltages BC and AB will be obtained. As the angle θ is now 60° and $E' = E''$, the above formula reduces to $\tan \phi = (2R'' - R')/(\sqrt{3} \cdot R')$. The actual wattmeter connections that have to be made vary somewhat according to the value and sign of the angle ϕ that is being measured. These various cases are considered, and in conclusion it is shown how the measurement may be corrected in the event that the voltages are unbalanced. A. J. M.

177. *Reluctance at Transitions between Sections of a Magnetic Path.* **F. Niethammer.** (Elektrot. u. Maschinenbau, 35. pp. 556–557, Nov. 18, 1917.)—If a cylindrical electrical conductor of radius r ends in an infinite conducting space, the current in passing from the conductor to the space has to traverse a transition resistance equal to a length ar of the cylinder, where $a = 0{\cdot}8\rho'/\rho$ and ρ, ρ' are the specific resistances of the cylinder and space respectively. The transition resistance $R_t = \rho ar/(\pi r^2) = 0{\cdot}8\rho'/(\pi r)$. A similar rule may be applied

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in the case of the magnetic circuit; for instance, at the transition between a pole and the yoke to which it is attached. If the pole is not in a single piece with the yoke, there will be an equivalent air-gap δ_t at the transition having a length $\delta_t = 0{\cdot}008$ to $0{\cdot}005$ cm. The magnetic transition reluctance from a pole of radius r will be given by

$$M_t = \alpha r/(\mu\pi r^2) = 0{\cdot}8/(\mu'\pi r) = 0{\cdot}25/(\mu' r),$$

where $\alpha = 0{\cdot}8\mu/\mu'$ and μ, μ' are the permeabilities of the pole and yoke respectively. The total reluctance of the joint is therefore

$$M'_t = [\delta_t/(\pi r^2)] + [0{\cdot}25/(\mu' r)].$$

If the periphery of the pole is $P = 2\pi r$ and its section is $S = \pi r^2$, then $M'_t = [(\delta_t/S)] + [0{\cdot}18\ P/(\mu' S)]$. If X is the number of amp.-turns required for the joint, then $0{\cdot}4\pi X = M'_t\Phi$, where $\Phi = B_t S$ is the flux, and

$$X = 0{\cdot}8B_t[\delta_t + (0{\cdot}8r/\mu')] = 0{\cdot}8B_t[\delta_t + 0{\cdot}18P/\mu'].$$ A. J. M.

178. *Inductance and Capacity of Conductors.* **J. Fischer-Hinnen.** (Schweiz. Elektrot. Verein, Bull. 8. pp. 333–365, Dec., 1917. *Errata*, 9. p. 19, Jan., 1918.)—Although much has been written on the subject of the inductance and capacity of transmission lines, yet the information available is mostly of a theoretical nature and mainly applicable to the simplest cases only. The present article attacks the problem more from a practical point of view, and shows how formulæ may be deduced in a simple manner for the systems of conductors that are met with in practice. The inductance of a single loop forms the basis of the calculations under this heading. This is obtained by determining the resulting flux produced by the outgoing and return conductors, which is divided into three parts: (1) the flux inside the wire, (2) the flux within the loop, (3) the flux linked with both conductors. If L is the coefficient of self-induction for the loop as calculated from the first two fluxes mentioned above, the value L/2 must not be confounded with the value of the coefficient of self-induction of a single wire as calculated by many authors. The methods are applied to the evaluation of the inductance of single-phase railways, of massive conductors such as are used in metallurgical processes, and of polyphase transmissions. In each case the calculated values are compared with values actually obtained in practice. Under the heading of capacity some theoretical computations are first made of the capacity of various assemblages of conductors. The formulæ thus obtained are then applied to the cases of single-phase lines and polyphase lines, both for overhead transmissions and for cables. The case of a trolley wire hung within a tunnel is also worked out. The values obtained for the different systems thus examined are compared with actual test values in each case. Tables are given of formulæ relating to the inductance and capacity of 40 arrangements of single-phase and polyphase transmission lines. A. J. M.

179. *Pennsylvania Electric Code.* (Eng. Club. Phil., Proc. 34. pp. 450–476, and 498, Oct., and pp. 506–514 and 539–545, Nov., 1917.)—The code was adopted by the Industrial Board of the Pennsylvania Department of Labour and Industry and became operative on July 1, 1917. First of all are given a number of definitions of special terms (58 altogether) and then follow the rules covering the method for protective grounding of circuits, equipment and lightning arresters for station lines and utilisation equipment (Paragraphs 90 to 585). L. H. W.

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180. *Electric Welding.* **J. Caldwell.** (Inst. Eng. and Shipbuilders, Trans. 61. pp. 26–56; Disc., 56–59, Jan., 1918. Abstracts in Electrician, 80. pp. 680–682, Feb. 15, 1918. El. Rev. 82. pp. 77–79, Jan. 25, 1918.)—The author gives a general description of the principal modern systems of electric welding. Under the heading of resistance welding, the various processes of butt-welding, spot-welding, and seam-welding are referred to, and particulars given of the purposes for which they are employed. In the author's opinion the coated metal electrode is superior to the bare metal electrode, as the latter oxidises on the surface, and the deposited metal is more or less oxidised by contact with the air in its passage across the arc. This oxide is liable to get into the weld, forming flaws; the bare metal also dissipates a good deal of heat, thus wasting energy. The fluxed-metal arc process is considered to be of the greatest promise for constructional work, and trials made on full scale show that in some respects it is superior to riveting.

Alternating-current generators must be used for resistance welding, and d.c. generators for carbon arc welding. Alternate current may be used for metal arc welding, but direct current is better. Steadying and regulating resistances are necessary in arc welding to limit the current flowing. A supply at from 100 to 110 volts should be available to overcome the resistance of the liquid flux, although less pressure is sufficient to maintain the arc with both carbon and metal electrodes. For resistance welding the supply pressure is not material. Where the supply is single-phase at, or about 100 volts, it can be connected directly to arc welders with only the regulating resistance in series. If the supply pressure is above 100 volts, static transformers, with separate windings, should be employed. In the case of a 3-wire 2-phase distribution, a single-phase supply can be obtained from the two outers. A single-phase current can be obtained from a 3-phase supply by using a transformer whose secondary windings are connected up in a particular way, but the out-of-balance voltage is considerable, and the power-factor is reduced. If the supply for arc welding is generated on the premises, or supplied through a transformer or motor-generator, the lead to which the work is connected should be earthed. Where the power supply is small compared with the current required for welding, a substitution resistance is used, and some automatic device to put the resistance in circuit when the arc is broken. Repair work requires superior, skilled operators. For boiler and ship repairs a boilermaker is suitable; for engine and machinery repairs a fitter will be better after suitable training. R. J. W.-J.

181. *Metal Cutting with the Electric Arc.* **G. Kearney.** (Gen. El. Rev. 20. pp. 876–880, Nov., 1917.)—Tests were made with a 30-kw., 60-volt arc-welding set installed in a rolling mill, where scrap iron and steel are worked up into standard shapes. The scrap metal is cut to suitable sizes and made into faggots of regular size and weight before being placed in the furnace for conversion into billets. The electric cutting apparatus is used for cutting up scrap which is too large to be handled by shears.

The apparatus is operated at 400–500 amps., and with these current values a carbon ¾ in. in diam., having a taper point 4 in. long, tapering to 3/16 in. diam., is quite satisfactory. The carbon when new is gripped in the holder about ¾ in. behind the beginning of the taper, and is moved about ¾ in. at a time as it consumes. The shape of the taper point is well maintained throughout the life of the electrode. Gripping the carbon further back causes the carbon to waste uniformly throughout its length, whereby, after

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about an hour's operation, it is reduced to some 3/16 in. diam. and 5 to 6 in. long. Owing to the increased resistance of the carbon the current falls to about 150 amps., greatly reducing the cutting speed. Special electrode holders, and special clamps for connecting the positive lead to the work, are described. The apparatus is particularly useful for cutting steel plates where an accurate or sharply defined edge is not essential. A table is given showing results of operation on a 9/16 in. steel plate, of which a summary is given below. The original plate was 18 ft. × 4ft. × 4 in., and was cut into seven pieces approximately 26 in. × 52 in., and one piece 32 in. × 52 in. This last piece was then cut in halves across its 32-in. length. The current averaged 400 amps.

Total length of cut	33 ft.
Total time	2 hrs. 14 mins.
Time actually cutting	95 mins.
Total time per ft.	4·07 mins.
Average net time per ft.	2·78 mins.
Total weight of plate (calculated)	1800 lbs.

COST OF CUTTING.

Power—	
56 kw-hrs. (estimated, including free running losses when not cutting) at 1 cent	$0.56
Electrodes—	
2 carbons at 20 cents	0.40
Labour—	
Operator, 2¼ hrs. at 40 cents	0.90
Helper, ¼ hr. at 30 cents	0.08
Fixed charges on plant	0.22
Total cost of 33 ft.	$2.16
Cost per ft.	0.065
Cost per ton	2.40

The arc apparatus replaced on oxy-acetylene outfit which had been installed to do the same work. The cost of the work by the oxy-acetylene method is estimated at $11 per ton. In addition to this, two explosions of gas tanks occurred, in which the operators narrowly escaped serious injury.

An effective job was made in cutting openings and bolt-holes in a shell for a steel furnace made of ½-in. steel plate. The net time taken to cut a ½-in. hole was 8½ secs.

In cutting plate the material should be laid flat, so that the molten metal drops away freely. The cut should be started at the side farthest from the operator, and the insulated shield of the holder can be rested on the work. A good chalk mark can be easily followed. The point of the electrode should be kept as close to the surface of the plate as possible, but a short distance back from the end of the cut. In thick plates it should be moved to and fro downward from this position to force the arc to the bottom of the plate. In cutting round sections such as shafting, the cut is started at the bottom, cutting straight across as deeply as possible, and if practicable turning the work so as to keep cutting from the bottom. A 2½-in. shaft is cut in 2½ to 3 mins., and a 4-in. shaft in 10 to 12 mins., leaving a small piece in the centre which can easily be broken off cold. R. J. W.-J.

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182. *Factors affecting the Application of Motors to Lathes.* C. E. Clewell. (El. World, 70. pp. 1238–1242, Dec. 29, 1917.)—The lathe is taken as a typical class of machine tool with which motors are used, and some of the practical points relating to the application of the motor are discussed in detail. No special reversing mechanism is required since reversal is necessary only occasionally, and may then be accomplished by the drum machine-tool controller. In most cases the question of possible work-diameter and necessary changes in speed is important. The power requirements are made up of the power required to remove a certain volume of metal per min. (this being a fairly definite factor for each particular metal) and of the power needed to overcome losses in the lathe itself. Sometimes one of these power components is predominant: sometimes both must be considered. The best means of ascertaining the power required is to use a test motor to drive the lathe under operating conditions; the actual input being measured by a recording ammeter. In estimating power needed to remove a certain volume of metal per min. the maximum as well as the mean rate of removal should be considered. When working from a graphic record of the power absorbed by a test motor, the peak h.p. to be provided is immediately evident, whilst the R.M.S. horse-power may be calculated from the R.M.S. current input, knowing the supply voltage and motor efficiency. The R.M.S. current $= \sqrt{[(\Sigma I_1^2 t_1)/T]}$; where $I_1, I_2 \ldots$ = current flowing for periods $t_1, t_2 \ldots$ seconds, determined from the ammeter record; and T = total duration of duty cycle including any periods of no current flow.

The spindle speed of the lathe depends directly on the cutting speed and inversely on the diam. of the work. The use of high-speed tool-steel instead of carbon tool-steel has made it possible to increase the cutting speed from 20–40 ft. per min., for soft steel, up to 80–160 ft. per min.; and up to 50–75 ft. per min. for cast iron. Finishing speeds are yet higher. There is for each material and each class of operation a "most economical cutting speed." This should be used as nearly as possible; higher speed is destructive and lower speed increases the cost of production. In order that any desired cutting speed may be secured on any diam. of work, we must use either mechanical speed-changes or a motor with sufficient speed range and gradation. The author gives examples, showing the superiority of a variable-speed electric motor over countershaft and cone pulleys, in point of speed gradation. A motor with a 4 : 1 speed range and a 5 : 1 back gear forms a useful combination. There is a gap between the lowest speed obtainable with back gear out and highest speed with back gear in, which gap should be kept down to 15–25 %. Electrical speed control by a modern controller gives finer gradation than mechanical speed-changes; also, it is far more convenient in location and operation, and offers no temptation to the operator to run at other than the best speed for each operation. Face-plate controllers may be used for small lathes, but the combined drum and dial type is more generally useful.

The application of motors to old belt-driven machines often makes it necessary to mount the motor as a separate unit, and possibly to use a countershaft, but the modern tendency is to make the motor an integral part of the machine. R. E. N.

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GENERATORS, MOTORS AND TRANSFORMERS.

183. *Design of Commutating Poles.* **K. H. Schübbe.** (Elektrot. u. Maschinenbau, 35. pp. 453–457, Sept. 23, 1917.)—Commutating poles are generally designed by rough estimation, and it is then left to the test-room to make the adjustments necessary to obtain good commutation. The article gives methods of more exact calculation based upon the results of experience with a large number of machines. The function of commutating poles is to compensate the reactance voltage generated in the short-circuited coils. If the cores are too highly saturated the compensation will not remain correct at overloads, as the field will not increase proportionally to the load current. A further action of the commutating poles is to tend to maintain the resultant flux in the geometrical neutral axis and thus render the shifting of the brushes with the load unnecessary. If the nature of the machine is such that the resultant field shifts appreciably with the load, then compensating windings must be used in addition to the commutating poles.

The necessary commutating field should be produced by a total number of amp.-turns AT_k, that is composed of a number AT_a equal to the armature amp.-turns and an excess number AT_ϵ required to produce the commutating field, the value of AT_ϵ being approximately 20 % of AT_a. As AT_a is given by the armature design, suitable conditions can only be obtained by properly choosing AT_ϵ.

Using wrought-iron poles the normal strength of the commutating field lies between the limits 1500 and 2000 c.g.s. at full load. The flux density of the commutating field is given by $B = AT_\epsilon/(0{\cdot}8\delta)$, where δ is the length of the air-gap, and if Q is the number of ampere-conductors per cm. on the circumference of the armature we may write $B = FQ$, where F is a commutation factor. These relations enable the length of the air-gap and the dimensions of the commutating poles to be suitably chosen so as to obtain such a relation between the sections of the pole-faces and pole cores that the flux in the cores is not excessive at the highest load. The factor F is calculated for a large number of machines of different types and the values are plotted at a function of B for wrought-iron commutating poles. For $B = 1000, 1500, 2000, 2500, 3000, 3500$ the corresponding mean values of F are 3·3, 5·0, 6·5, 7·7, 8·6, 9·3. For the machines in question the strength of the commutating poles was adjusted by test by measuring the voltage from the commutator segment under the leading edge of the brush to the trailing-edge of the carbon brush. This voltage should be nearly zero for the best commutation, and will increase towards the trailing edge for under-commutation and decrease for over-commutation. The variations of F from the mean value were greatest at high values of B.

It is concluded that, if the cores and pole-faces have the same tangential width, the normal field strength in the core should be about 1800 with a value of $F = 6$. The pole-faces should be wide enough to cover the short-circuited commutator segments and the air-gap under the commutating poles should be 25 to 50 % greater than the air-gap under the main poles in order to prevent strong flux variations caused by the teeth. It is desirable to place the pole-faces at an angle to the line of the slots. With compensated machines the amp.-turns AT_ϵ should be divided so that about 2/3 are situated in the compensating winding and 1/3 on the commutating-pole

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winding. Experience shows that good commutation is obtainable with softer brushes than are commonly used, which has the advantage of reducing the friction losses and the contact resistance. The results obtained are applicable to machines with iron commutators, and with proper design such machines have good commutating properties. A. J. M.

184. *Modern Dynamo-electric Machinery.* **A. Gray.** (Frank. Inst., J. 188. pp. 15–48, July; 184. pp. 205–226, Aug.; 409–488, Sept., and pp. 558–567, Oct., 1917.)—The paper contains a discussion of the relations which exist between the size, speed, and output of various kinds of dynamo-electric machinery, and a comparison between the results obtained at the present day with those which were obtained 10 and 20 years ago. The curves of Fig. 1 show how the output coefficient of d.c. machines has increased. The

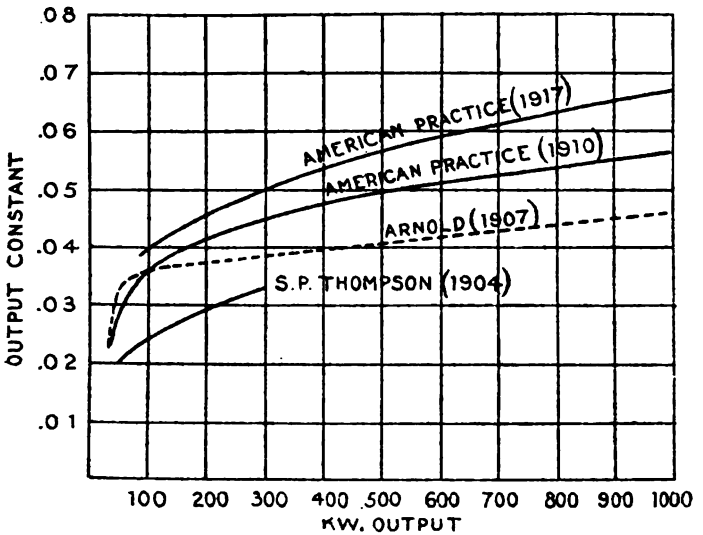

FIG. 1.

output coefficient considered is defined by: Watts output/ND^2L, where N = revs. per. min., D = external diam. of armature (inches), L = length of armature core (inches). The output of a non-interpole machine of given size is limited by the sparking or reactance voltage; in an interpole machine it is limited by the voltage between adjacent commutator segments which is influenced by the distortion of the field, and in interpole machines with pole-face compensating windings the same limit is met but the effect of distortion is removed. Assuming a max. permissible peripheral speed of 9000 ft./min. for the armature, a max. reactance voltage of 2·5, max. voltage per segment of 15 for plain interpole machines and 20 for compensated machines, a mean gap density of 60,000 lines/in.^{2} with a pole spread of 0·7 of the pole pitch and 1100 amp.-conductors per inch, the max. possible outputs are shown to be 380,000/r.p.m. for non-interpole machines, 900,000/r.p.m. for plain interpole machines and 1,200,000/r.p.m. for compensated interpole machines. These figures may be increased only by the adoption of higher peripheral speeds and armature windings with one slot conductor per commutator bar.

The limits met with in the design of low- and medium-speed alternators are (*a*) regulation, (*b*) temperature-rise. The tendency to use automatic

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voltage regulators has removed the necessity for close inherent regulation; the following table shows the change which has taken place:—

Date.	Per Cent. Regulation.	
	Power-factor = 1·0.	Power-factor = 0·80.
1900	5	15
1910	8	20
1917	20	40

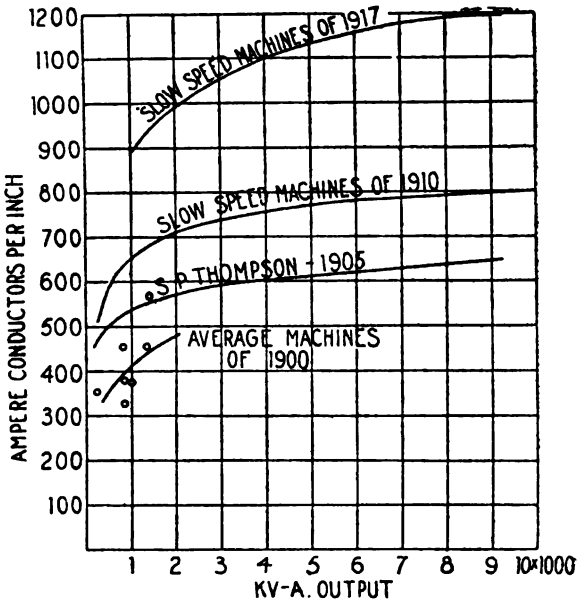

FIG. 2.

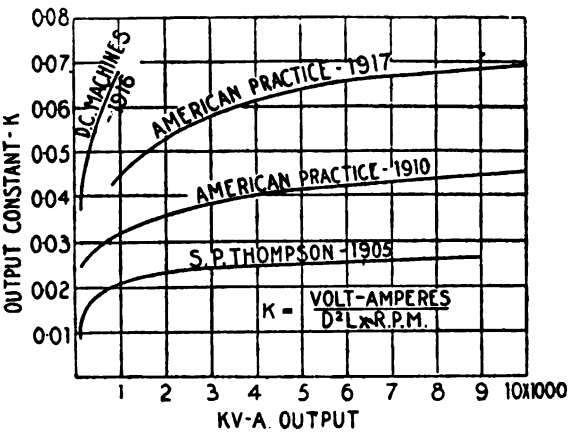

FIG. 3.

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The development of satisfactory systems of ventilation and the permission of higher operating temperatures have also led to increased outputs. Figs. 2 and 3 give interesting comparisons of design coefficients.

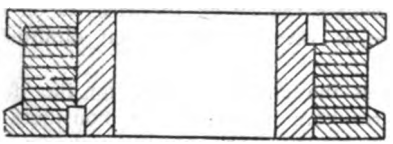
Rapid progress is being made in the output obtained from turbo-alternators. The relations between output and size are largely determined by the permissible peripheral speed of the rotor, the system of ventilation adopted, the temperature-rise allowed, and the degree of regulation which is considered necessary.

In the design of rotary converters marked development has taken place; commutating poles and complete squirrel-cage damping windings are widely employed, and the construction of commutators has been so much improved that peripheral speeds of 5400 ft./min. may be used safely, and 60-cycle machines may have 48 commutator segments per pole. The following table shows the kind of change which has taken place:—

Date.	Poles.	Kw.	Revs. per min.
1906	10	1000	514
1910	8	1000	750
1916	6	1000	900

F. T. C.

185. *High-speed Slip-rings.* (U.S. Pat. No. 1,248,286. El. World, 71. p. 95, Jan. 12, 1918. Abstract.)—Materials of very high tensile strength yield a suitable factor of safety when used for slip-rings in high-speed dynamos, but they have relatively low conductivity; this is especially serious where heavy currents have to be carried. Also, copper from negative copper



brushes is deposited electrolytically on slip-rings and results in heavy sparking. W. Gscheidlen (Berlin) suggests the use of a metal strip or band wound on edge to form a cylindrical spiral with turns pressed firmly together. Pins are used to hold the rings in place (see Fig.). Such a slip-ring has a higher peripheral tensile strength than can be obtained from cast or pressed metal. R. E. N.

186. *Cooling the Ventilating Air for Generators.* **J. T. Foster.** (El. World, 71. pp. 84–85, Jan. 5, 1918.)—The author states that if the ventilating air is cooled, the output of a generator can be increased from 10 to 20 %. The pre-cooling would be combined with the air-washing process: it is done by evaporating the water when the air passes through the film of water, atomised by the spray nozzles. Diagrams are given showing the relation between rating, amount of cooling air required per min., cost of air washer, and cost of washer installed complete. The author examines theoretically the case of cooling a 12,500-kw. generator, and finds the output would be increased 28 %; he thinks the gain would actually amount to about 15 %, though higher figures have been obtained in practice. A drawing shows a typical arrangement of air-precooling apparatus for a turbo-generator. W. H. S.

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187. *Loss of Energy in the Starting Rheostats of Direct-current and Induction Motors.* **J. Saint-Germain.** (Rev. Gén. d'Él. 8. pp. 15–16, Jan. 5, 1918.)—The author makes an application of a method already given by him [Abs. 612 (1917)] for the particular case in which the unknown quantity is the energy spent in the starting rheostat and the driving torque, the resistant torque, and the duration of the starting period are known. The general formula arrived at is $W = (S'/S)PT$, where W is the energy spent in the rheostat in kw.-secs., P the normal power of the motor in kw., T the duration of the starting period in seconds, and S and S' are two particular surfaces of the graphic diagram. The three special cases already considered in the former article are considered also in this article and the corresponding formulæ are derived. E. B.

188. *Induction Motors with High Power-factor and Speed Regulation.* **R. V. Picou.** (Soc. Int. Élect., Bull. 7. pp. 311–319, Dec., 1917.)—If an internally excited machine of the type already described by the author [Abs. 56 (1914)] is mechanically coupled to an ordinary induction motor and if the current of the former machine is allowed to flow through the rotor of the latter, a power-factor practically equal to unity and a regulation of the speed from a negative value to almost that of synchronism can be obtained. The excitation of the auxiliary machine is derived from the polyphase main through step-down transformers having their secondaries connected in series with the secondaries of the compounding transformers, through the primaries of which flow the currents feeding the induction motor. The auxiliary machine acts as a generator of polyphase currents of the same frequency as those of the rotor of the induction motor and of a phase depending upon the angular position of the brushes. If the compoundage is just sufficient, the speed is independent of the load: if the compoundage is in excess, the speed increases when the load increases: if the compoundage is inverted, the speed diminishes when the load increases.

The author utilises the circle diagram for the demonstration of the properties of the resultant machine and considers the possibility of diminishing the air-gap and the dimensions of the commutator of the auxiliary machine. E. B.

189. *A New Type of Enclosed Motor.* (El. Rev. 82. pp. 81–82, Jan. 11, 1918. Electrician, 80. pp. 578–579, Jan. 18, 1918.)—This motor is designed by P. A. H. Mossay and H. C. E. Jacoby. The air is circulated inside the motor through a cooling system, cast integrally with the frame in such a manner that the external dimensions are not appreciably increased. In the case of a.c. motors the cooling chambers are virtually channels cast in the webs that support the laminæ, and in d.c. motors the cooling system consists of chambers cast in the magnet ring in such a manner as not to interfere with the distribution of the magnetic flux. It is claimed that with a motor of this type the output for a given temperature-rise is even greater than that of an open-type motor of equal bulk and weight. Curves are given showing the results that have been obtained under test, and a drawing is also given showing the general nature of the proposed construction.

W. H. S.

190. *Voltage Characteristics of Motor-generator Sets.* **W. B. Kouwenhoven.** (El. World, 71. pp. 188–189, Jan. 19, 1918.)—The article discusses the possibility of predetermining the voltage characteristic of motor-

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generator sets from the voltage characteristic of the generator at constant speed and the speed characteristic of the motor. It is concluded that this problem is easily capable of solution for shunt generators if their fields are highly saturated and also for compound generators. In these cases the resulting regulation of the combination may be deduced from the voltage regulation of the generator and the speed regulation of the prime mover. It is shown that for shunt generators the change of voltage corresponding to a change of speed from n_1 to n_2 is less than that given by the ratio $(n_1/n_2)^2$ and greater than that given by the ratio (n_1/n_2). If the field is highly saturated it was found possible to obtain the generator unit load characteristic by subtracting from the generator characteristic at rated speed ordinates equal to the drop in voltage between the no-load voltage at rated speed and the no-load voltage at the lower speed for which correction is desired, *i.e.* the two curves are parallel to each other. A similar process is applicable to the case of compound generators. The values obtained for the terminal voltage are found to be correct within $\pm$ 1 %. A. J. M.

191. *Parallel Operation of Three-phase Transformers.* **J. Damien.** (Rev. Gén. d'Él. 2. pp. 764–767, Nov. 17, 1917.)—Comparing the merits of transformers with star- and delta-connected windings, the author concludes that the advantage lies with star-connected windings, because there is less chance of error in making the connections. The general conditions to be fulfilled in order to secure good parallel operation are discussed, and the following recommendations are made: (1) The circuits should be balanced to within 10 %; (2) consumers' circuits should be protected by triple-pole switches; and (3) the transformers should be protected by overload and reverse-current circuit-breakers on the high-tension side. F. T. C.

192. *Parallel Connection of Transformers.* **R. Hiecke.** (Elektrot. u. Maschinenbau, 35. pp. 597–602, Dec. 16, and pp. 615–617, Dec. 23, 1917.)—When transformers are connected in parallel on their primary and secondary sides, unequal division of the loads is likely to occur. This results from differences in the resistances of the leads between the transformers and the common bus-bars, in the ratio of transformation, or in the short-circuit voltages. Differences in the ratio of transformation causes circulating currents to flow that are nearly independent of the load, whereas differences in the short-circuit voltages give rise to circulating currents that increase with the load and vanish at no-load. The best remedy is to connect choking coils and resistances in circuit with the individual transformers. The article consists of a series of calculations from which formulæ are derived for the determination of the currents flowing in the individual members of a bank of transformers, the characteristics of which are known. These calculations are lengthy, and not suitable for abstracting. A. J. M.

193. *Electric-wave Phenomena in the Dynamo-electric Machine.* **F. Creedy.** (Inst. El. Eng., J. 55. pp. 450–472, June, 1917.)—This paper is of a nature unsuited for brief abstracting, and should be referred to in the original. L. H. W.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

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194. *Voltage-drop in Three-phase Cables.* **A. Peukert.** (Vereinig. d. Elektrizitätswerke, Mitt. No. 199. 1917. Elektrot. u. Maschinenbau, 35. pp. 628–629, Dec. 30, 1917.)—It is not sufficient to determine the voltage drop in each branch of a network by application of Ohm's law. G. Rossler's method has found no favour in practice, because calculation with symbolic magnitudes is not simple, and cable works do not state the Rossler values. The author's method may be applied to networks of medium pressure to determine whether the voltage-drop within the range of working conditions departs considerably from values found by the first method. The cable under examination is short-circuited at one end, and is supplied at the other end with current of different strengths. The voltages measured equal the voltage-drop which occurs on non-inductive load with the same current values. The ohmic resistance of the cable, hot and cold, was measured before and after the test. Proportionality was found to exist between the voltage values (reduced to 1 km. basis) and the current strength, namely, $e_v = ai$. The ohmic drop per km. in 3-phase cable of section q is $e_v = i1000\sqrt{3}/60q$; hence $a = 1000\sqrt{3}/60q$. Test data are given in the table :—

Section, mm.².	Length, m.	e_v Measured.	Measured greater than calculated by, %.	Cos ϕ_c
3 × 16	3875	$1{\cdot}925\,i$	6·94	0·98
3 × 25	3701	$1{\cdot}285\,i$	7·2	0·99
3 × 50	3621	$0{\cdot}649\,i$	12·5	0·96
3 × 95	3307	$0{\cdot}876\,i$	24·1	0·88
3 × 15	3274	$0{\cdot}278\,i$	42·2	0·80

The power-factor, cos ϕ_c, of the cable itself was determined by the two-wattmeter method; in all cases the cable took inductive current on short-circuit. Curves in the original show the measured e_v as percentages of the calculated values and the power-factor as function of the conductor section. The voltage OC to be provided to secure a voltage OA at the far end is the vector sum of OA and AC, where AC equals the ohmic drop (which may lag ϕ with regard to OA), but has a lead of ϕ_c on this ohmic drop due to the fact that the cable itself imposes a lag on the current. The accuracy of this method was verified on a 10,000–11,000-volt cable. R. E. N.

195. *Comparative Cost of Steel and Wooden Pole Transmission Line.* (El. Rev., Chicago, 72. p. 168, Jan. 26, 1918.)—Figures are given showing the cost at present prices of wooden poles and steel towers for a line transmitting power at 100,000 volts. It is estimated that the cost of providing and erecting wood poles would be about 75 % of that for steel towers. W. H. S.

196. *Iron Wire for Transmission Purposes.* **D. D. Ewing.** (El. World, 70. pp. 1252–1253, Dec. 29, 1917.)—The high charging current mentioned by Leslie [Abs. 61 (1918)] would have been little different if copper wires had been used instead of iron. The physical qualities of the conductor material

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do not affect directly the charging current. The line inductance in series with the load does little to minimise the charging current due to line capacity in parallel with the load in the case of lines of the physical dimensions employed in the Dodge City–Mineola transmission. Inductive apparatus installed at points along the line is effective, but it does not pay to install it solely for the purpose of reducing transformer and line currents. The real solution is to secure induction-motor loads (*e.g.* village pumping plant) or other loads of relatively low, lagging power-factor. This is just the opposite of the type of load generally desired by central station operators. The operating characteristics of a proposed line should be predetermined carefully; a few comparatively simple calculations results yield sufficiently accurate for estimating purposes. The condition for minimum line loss is approximately that the current at the load end should contain a lagging component equal to half the charging current of the line. Vector diagrams in the original show the phase and magnitude of the charging current with unity power-factor load and at the power-factor giving minimum line loss. R. E. N.

197. *Voltage-rises.* **G. Benischke.** (Elektrot. u. Maschinenbau, 35. pp. 609–614, Dec. 23, 1917. Paper read before the Elektrot. Verein, Munich.)—Voltage-rises in high-tension networks originate either in atmospheric causes or through occurrences in the network itself. The paper is concerned with the latter only. The phenomena have been copiously discussed mathematically, but the conclusions arrived at are vitiated by false assumptions made and the neglect of features that are omitted to simplify the mathematics. The general result has been to overestimate the dangers of voltage-rises and the calculations must be taken to give an upper limit to the voltages that may occur. There are five types of voltage-rises: (1) *Voltage-rises due to sudden breaking of circuits.*—These are damped by eddy-currents in the conductors and can only reach dangerous values if the break is *sudden*. Arcing at the contacts lengthens the break and lowers the voltage-rise. (2) *Voltage-rises due to resonance.*—These only occur with cables or long overhead lines, as otherwise sufficient capacity is not present. The capacity and reactance of such lines usually lie in parallel, and not in series as is required for resonance. Series resonance is only obtained if a piece of apparatus is connected to the generator on one pole, or if a generator is loaded by an open cable, or if one pole of a line becomes earthed. These three cases are explained and it is shown that resonance with the fundamental is not to be feared in normal installations. Danger is only to be feared when higher harmonics are present. Harmonics of orders between the 11th and 89th are often introduced by the teeth of alternators, and for these the resonance capacity or inductance are reduced in magnitude 121 to 1521 times. These harmonics should be avoided by suitable design of the generators. (3) *Voltage-rises on closing circuits with capacity and inductance.*—This operation causes damped oscillations which are superposed on the voltage wave in the case of alternating currents. The greatest possible voltage is twice the max. value of the applied voltage, but this value is not reached in practice, owing to the damping effect of line resistance and of hysteresis and eddy currents in masses of iron. These rises are most dangerous in poorly insulated low-tension circuits and throw great stresses on the windings of transformers and machines. Travelling surges are produced, but their effects have generally been greatly overestimated owing to the assumption being made that the wave-front is quite steep, which is not in accordance with the physical facts. The short duration and small energy

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of such surges lead to very minute punctures in the insulation which are liable to start troubles of a serious nature. These surges may be prevented by avoiding the presence of capacity, by using switches with a succession of steps that introduce resistance before closing the circuit, or, preferably, by inserting choking coils with iron cores and few turns into the circuit to be protected at either end of the transmission line. The use of iron cores is important, as the reflection of the surges is rendered more complete thereby and as the part of the surge that penetrates the line is strongly damped by the eddy currents and hysteresis losses in the iron core. In the case of transformers the end turns may be insulated particularly heavily and these turns then serve in the place of a separate choking-coil. The protection afforded by the use of condensers is a limited one, as the condensers can only be connected in parallel with the apparatus to be protected and because the introduction of condensers may give rise to resonance phenomena. In a particular installation referred to, condensers to a value of £12,000 had to be discarded owing to the troubles that were found to be associated with their use on connection to the circuit. (4) *Voltage-rises due to undamped oscillations.*—These may be introduced by arcs, and high voltages may be developed by transformer action in circuits electromagnetically linked to the circuit of the arcs. This condition is infrequently met with. (5) *Voltage-rises due to unsymmetrical loading on polyphase systems.*—If a very heavy load, such as a short-circuit, occurs on one phase, the voltage on the remaining phases rises owing to unsymmetrical distribution of the magnetic field. Voltage-rises due to the various causes discussed may be prevented by using the devices referred to above or by connecting metal or liquid-jet resistances between the conductors and the earth. A. J. M.

198. *Surge Phenomena accompanying Transmission with Star-connected Transformers.* **L. N. Robinson.** (Am. I. E. E., Proc. 86. pp. 967–997, Dec., 1917.)—It is inadvisable to use single-phase transformers connected star-star on a three-phase circuit, as unstable conditions are liable to arise that jeopardise their insulation. The troubles that are likely to occur are due to the fact that hysteresis and variation of permeability give rise to harmonics of considerable magnitude in the exciting currents of the transformers. An investigation shows that the hysteresis introduces triple-harmonic components of exciting current in quadrature with those introduced by the variation of permeability and of practically half the magnitude of the latter. The harmonic components of the exciting current will flow in a closed circuit, if such be provided, and will give rise to energy losses. It is therefore not correct to suppose that the harmonics in the exciting current of a transformer are entirely wattless. A number of transformer connections are examined and the path of the triple-frequency currents is followed out. In the star-star system with a 4-wire primary the triple-harmonic voltage components are established in the primary of the transformers. The triple-frequency currents flow through the neutral as a common wire, thence they pass through the generator windings and return through the line wires. If the fourth wire on the primary side be removed, the harmonic components of the exciting current cannot flow and the flux waves are badly distorted in consequence. As the third harmonic component in the voltage from line to neutral may be 60 % of the rated fundamental component, a serious extra strain on the insulation may be caused. The paper is mainly concerned with the case of a star-star system with earthed neutral on the load side only, the distributing system that is being fed being extensive and having a large capacity. In this

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system there is no path for triple harmonics in the primary but the admittances between the line conductors and earth enable these currents to flow through the secondary windings with the neutral as the common wire, and thence through the admittances between the neutral and the line conductors back to the neutral point. The currents so flowing are often accompanied by serious vibrations and noises issuing from the transformers, and may cause one leg of the bank of transformers to reverse once for each fundamental cycle, so that the fundamental component of the current in that leg tends to flow in the same direction during the entire cycle. Owing to the shape of the hysteresis loop the inductance in the circuit varies for different values of the applied voltage and for a particular value of this voltage the circuit may become resonant, *i.e.* when the reactance of the transformers becomes equal to the capacitance of the lines. When this is the case the objectionable surging referred to arises. A number of laboratory tests are described in which these conditions are imitated and oscillograms are given showing the surges set up. [See also Abs. 981 (1915).] A. J. M.

199. *Piping for Outdoor Bus-bar Work.* **M. M. Samuels.** (El. World, 70. pp. 1236–1237, Dec. 29, 1917.)—Copper, brass, and iron pipe is used extensively for bus-bars and connections in the h.t. parts of outdoor substations, with the great advantage that it can be supported on rigid insulators instead of by strain insulators. The spacing of insulators must be determined for each case; if the conductor runs parallel to a steel member the ground clearance is decreased if the steel member be below, and increased if the steel support be above the bus-bar. The actual ground clearance at max. sag depends upon the height of the insulator. Greater sag and greater distance between insulators is permissible when the bus-bar runs transversely across or is suspended below the steel member. Specially long pins must generally be provided if the bus-bar is to be carried above and parallel to a steel support. Curves are given, showing the deflection of ordinary and extra heavy copper, brass, and iron piping from $\frac{1}{2}$ to 8 in. diam., in spans up to 35 or 40 ft., both with $\frac{1}{2}$ in. ice load and without ice load. The deflections are for two end supports; the deflection in a continuous pipe with more than two supports is considerably less. To connect a pipe to a terminal the end may simply be flattened, drilled, and used as a lug. R. E. N.

200. *Sectionalisation of Overhead Wire for Three-wire Operation.* **E. R. Shepard.** (El. Rly. J. 50. pp. 1040–1041, Dec. 8, 1917.)—The three-wire system is being adopted in order to mitigate electrolytic effects, and it is necessary to take care that the wire is properly sectionalised if the best results are to be produced. Various diagrams are given, showing the effects on current and potential of different arrangements of the trolley wire.

W. H. S.

201. *The Mechanical Resistance of Electric Lines.* **A. Gronda.** (Elettrotecnica, 4. pp. 618–625, Dec. 15, 1917.)—This article is a general review of the technics of the construction of poles for electric lines. The L-irons constituting the members of the actual type of lattice masts could be replaced with great advantage by tubular irons. The author advocates a pole constituted of a central tube or lattice mast calculated against vertical forces, held by several systems of braces formed of round irons subjected to tensional stresses. This pole, though lighter and more economical than the actual lattice mast, is, possibly, less æsthetic in appearance and requires a larger base. The author studies the different forces acting upon the poles under

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ordinary and exceptional conditions and gives an abac for laying down the wires, constituted by a family of parabolas and a family of hyperbolas, the abscissæ being the lengths l of the span and the ordinates the quantities $\lambda = (s-l)/l$, where s is the length of the wire. The quantity λ can be called the "percentual increase of length of the wire" and is due to the sag, to the temperature, and to the mechanical lengthening. Some examples demonstrate the use of the abac. E. B.

202. *Power Requirements of the Electrochemical Industry.* **F. A. Lidbury.** (West. Soc. Eng., J. 22. pp. 805–825; Disc., 825–844, May, 1917.)—The author divides electrochemical industries into three classes as follows :—

(1) Those which essentially belong to the country concerned.
(2) Those which have grown up in the country to as great an extent as is necessary, and may be still growing.
(3) Those which have not yet found a footing in the country.

After giving some interesting details of the extent to which electrochemical products are now being made, the author discusses their dependence on cheap power. In the U.S.A. very little power is available at less than $18 to $20 per h.p.-year. In some cases these costs have been too high to permit the industry to develop. In considering electric power in relation to electrochemical production, the transportation to the markets constitutes nothing more or less than another method of transporting electric power. It is subject to the same limitations. Just as it is not economical to transmit electric power beyond a certain distance, similarly there is a limitation to the distance to which power can be indirectly transported in the form of electrochemical products. The reason why electrochemical products are made so largely at Niagara, notwithstanding that cheaper water-power is available elsewhere, is that, Niagara is within 500 miles of all the principal markets where the products are being used. It is a simple matter, if we know the number of kw.-hours in the lb. or ton of the product, to calculate the distance to which such a product can be transported in terms of power costs. For example, aluminium, which is extremely light for the amount of power which it represents, takes a fairly low freight rate in comparison to the power consumption per lb. In this case it appears that a 8000-mile haul would be equivalent to something like $12 per h.p.-year. Consequently if the cost of power were $20 per h.p.-year in the Eastern States it would be necessary to have the cost of power at something like $8 per h.p.-year in the West in order to compete in the Eastern market. In many cases the difference is as much as $20 to $40 for every h.p.-year consumed, and in the case of caustic soda and bleach the difference works out at something like $800 per h.p.-year. These results take no account of the differences that might arise in the cost of raw materials.

In conclusion the author raises the question of "off-peak" power. The difficulty with such power is that the supply engineer wishes to relieve himself of a certain investment which he can only use for a comparatively short time per day, but he cannot give power for the whole 24 hours. That being so, it is necessary for the electrochemical manufacturer, if he avails himself of off-peak power, to make a large investment in plant in order to maintain his output. Assume the cost of a station to be $54 per kw. The supply engineer will give power at a rate in which he will not include capital charges on his $54 per kw. capacity, but the chances are that he is asking the electrochemical manufacturer to invest a good deal more than $54 per

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kw. capacity in order to take that power. The author states that in his experience it is generally better to pay the higher price for power so that it may be obtained for the whole 24 hours. W. R. C.

203. *The Power-factor.* **Rechniewski.** (Soc. Int. Elect., Bull. 8. pp. 18–19, Jan., 1918.)—The author advocates the use of over-excited synchronous motors for improving the power-factor. It is not easy to calculate the effects likely to be produced in any particular case, but generally speaking, it is considered that it would repay its cost in two or three years of working if a synchronous motor were installed. It is sometimes stated that the troubles of a low power-factor largely result from an improper design of the installation; but the author considers this view to be incorrect. He compares two hypothetical cases, and shows that the plan of installing an over-excited synchronous motor with a system having a power-factor of 0·9 is better for dealing with an output with a power-factor of 0·7 than the plan of installing throughout with this latter power-factor in view. The author also advocates the use of synchronous motors in all cases where there is no difficulty connected with starting, and where the load can be thrown on, when the motors have started. W. H. S.

204. *German Restrictions on Electricity Consumption.* (Elekt. Zeits. 88. pp. 541–542, Nov. 15, 1917. Official Decree.)—This Order by the Imperial Commissioner for Coal Distribution came into force on Nov. 2, 1917. By it the consumption of electrical energy, whether from central stations or private generating plant, is restricted to 80 % of the consumption in the corresponding month (or meter-reading period) in 1916. The right is reserved to restrict consumption in individual cases to a greater degree. Small consumers using less than 250 kw.-hrs. per annum are not affected directly by the order but local authorities are empowered to introduce more or less stringent restrictions according to local conditions. Where energy is used for munitions purposes or for other public service, the restriction may be removed if justified by circumstances. Ordinarily, installations in war service are also subject to the 80 % restriction, save that where extensions have been made, the consumption may be reduced to 80 % of the mean consumption during Aug.–Oct., 1917, instead of to 80 % of the corresponding month's consumption in 1916. Special consideration is extended to those who reduced their consumption voluntarily before the date of the order. Stations with reserve plant capacity and where it is not possible or necessary to reduce coal or oil consumption (*e.g.* water-power stations and certain concerns using brown coal or waste heat, etc.) are more or less completely exempted from this order. New connections and extensions are only to be sanctioned in cases of special urgency and where the station capacity is sufficient and the supply of fuel assured. Measures are to be taken, where necessary, to secure better distribution of load (as regards time of incidence). Engineers in charge of stations are to play a leading part in administering the order, but special provisions are made to cover all cases and circumstances. Where energy is consumed in excess of the permitted allowance, the surplus may be deducted from the allowance for another period; and an additional charge of 50 pf. per unit must be paid for the surplus. The order is enforced by penalties. R. E. N.

205. *Annual Load Relief Map, Peak Load, and Load-factor Analysis.* **W. Le R. Robertson.** (Am. I. E. E., Proc. 36. pp. 941–947, Dec., 1917.)—A detailed description of a method of visualising the entire load for 365

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days each year by plotting the daily load curve on cards cutting out the outline of the curve and stacking the cards in correct daily sequence. Photographs of such stacks of cards, forming load-relief maps, are given. The scheme enables the effect of daylight-saving (summer time) on the load to be apparent. Similarly excessive peaks and deep valleys in the load are emphasised in a manner not possible with daily curves recorded in books. The extent to which the plant can be used for the load without the necessity for extensions is shown with the relief map. H. A. Barre, of the Pacific Light and Power Corporation, Los Angeles, California, had used a similar map for several years in connection with certain analysis of the relative values of water-power and steam reserve in order to explain to the bankers' satisfaction how much power would be carried by the steam and hydro-electric plants respectively. W. E. W.

206. *Electrical Interconnection in the United States.* (El. World, 71. pp. 12–14, Jan. 5, 1918.)—This article deals mainly with New York State and California, and sets out facts intended to prove that the interconnection of various independent companies would tend to economise fuel, besides giving a better service in many districts. Extracts are given from reports on the subject that have been prepared by committees appointed to investigate the matter, and maps are given showing the nature of the proposed supply. In each case a number of connecting links would have to be constructed.
W. H. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

207. *Construction of a 66,000-volt Line.* (El. Rev., Chicago, 71. pp. 1009–1011, Dec. 15, 1917.)—This is a description of a transmission line, 8½ miles in length, over some difficult country in Virginia. Steel towers are used, and the line extends from the power-house at Wheeling to a transformer station at Moundsville, where the high-voltage power is transformed and distributed. Full particulars of the details of construction are given: the rocky nature of the soil together with rain, snow, and extreme cold made the work unusually difficult. W. H. S.

208. *New Power Station at Albany, N.Y.* **C. H. Bromley.** (Power, 46. pp. 72–78, July 17, 1917.)—A detailed description of the River Station, Municipal Gas Co., Albany, N.Y., a modern steam turbo-plant operating in parallel with the hydro-electric plants at Cohoes and Spier Falls. The station is on the Hudson River, and is of steel, concrete, and brick construction. The river flood water may rise 6 ft. above ground-level, but this has been provided for. The boiler-room floor is 10 ft. above highest flood-level, but the condenser basement is 14 ft. below and is therefore enclosed in a waterproof concrete box. The structural features of this are given with detail drawings. The turbine-room walls are faced with bricks having a coat of filler and three coats of a good quality mill-white paint. These saved the heavy cost of glazed white bricks. Coal storage is provided as follows: 80,000 tons in the yard, 2000 tons in concrete bunker, and 500 tons above the boilers. All coal stored outside is at times partly or wholly under water. A movable electric hoist, 45 tons per hour capacity, with ¾-ton bucket, is used for transporting purposes. There are two steel stacks 174 feet high, 9 ft. 6 in. in diam. unlined. In the boiler-room are five boilers, each having 6500 sq. ft. of

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heating surface, three 42-in. steam drums, and 294 four-inch tubes 18 ft. long. In each boiler is a superheater of 943 sq. ft. heating surface. The boilers are built for 225 lbs. pressure but are worked at 200 lbs. Draught is provided by two fans, 80,000 cub. ft. per min. capacity, each turbine-driven through gearing, and the turbine speed being 3540 r.p.m. and the fan speed 1182 r.p.m. The speed of the turbo-fans is automatically regulated by the air pressure in the draught duct. In the engine-room are installed two 7500-kw., 7-stage, 2400 r.p.m., 12,000-volt, 40-cycle turbo-generators, with room for a 15,000-kw. unit. A turbine-driven oil pump is used as auxiliary to the main oil pump, to supply oil to the bearings while the turbine is attaining speed. When normal speed is reached the turbine oil pump is automatically stopped. The condenser auxiliaries, circulating, air, and condensate pumps are turbine-driven, the circulating pump through gearing from a 117-h.p., 2500-r.p.m. turbine and the condensate and air pumps direct on the same shaft from a 2500-r.p.m. turbine. Each generator is fitted with an air-washer of 80,000 cub. ft. per min. capacity. W. E. W.

209. *Power Plant of the St. Joseph Lead Co.* **E. L. Broome.** (Power, 46. pp. 582–585, Oct. 30, 1917.)—This new steam-turbine plant has been installed at Rivermines, Missouri, to meet the growing demand on three existing stations, viz., two 1000-kw. steam turbo-generators at Leadwood, three gas-engine sets of 1620 kw. total capacity at Bonne Terre, and four gas-engine sets, 2160 kw., at Rivermines. The new site was selected to be near the load centre, for railroad facilities, coal storage, and water supply. The foundations are on rock 12 ft. below grade; reinforced concrete girders are used between the piers. The boiler-room, 119 ft. × 48 ft., contains seven Heine boilers, 518 h.p. each, with superheaters and chain-grate stokers of 124 sq. ft. area.

Flue breeching of unlined steel plate covered with 2 in. of magnesia leads to a radial brick stack 255 ft. high, 9 ft. internal diam. Coal, received on an elevated track, is dropped into a 80-ton steel track hopper from whence a 20-in. inclined belt conveyor takes the smaller coal direct to a 400-ton circular steel bunker 80 ft. in diam., lined with 4 in. of concrete. An 8-ton weighing hopper and automatic register are below the bunker. Larger coal is crushed before being fed to the belt. Duplicate horizontal helical conveyors, 12 in. in diam., extend from the weigher to the stoker hoppers. The fuel is uniformly moistened to avoid coking and dust. Two engines drive the whole stoker plant. There are two 3000-kw., 3-phase, 60-∿, 6600-volt Curtis turbo-generators with Leblanc jet condensers. The concrete spray-cooling ponds have 270 nozzles and 27,600 sq. ft. surface; a constant supply, about 1500 galls. per min., of cold mine water is connected in the return. The feed-water, 18 grains per gall. total hardness, is softened in two plants. W. N. Y. K.

210. *Automatic Power Plant at Cedar Rapids, Iowa.* (El. Rly. J. 50. pp. 980–985, Dec. 1, 1917. El. World, 70. pp. 1042–1045, Dec. 1, 1917. Power, 46. pp. 790–793, Dec. 11, 1917.)—The Iowa Railway and Light Co. have installed a hydro-electric generating station of 2000 kw. capacity to supply in parallel with a 19,000-kw. steam station about 3800 ft. distant. The Cedar River, 600 ft. wide, is spanned by a concrete dam of the automatic crest type, composed of nine spillway sections each 60 ft. wide. The power-house is 350 ft. from the dam, and the normal head of water is 10 ft., varying between 8 and 11 ft. The lowest recorded flow is 500 cub. ft. per sec., during four days in the year, and the highest is 50,000 cub. ft. per sec. during

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12 to 14 days; the average flow is 2100 cub. ft. per sec. Each water-wheel takes 720 cub. ft. per sec. at full load. There are four Francis single-runner wheels, each 171 in. in diam. and rated at 540 b.h.p. at 600 r.p.m. with 10 ft. head. The efficiency guaranteed by the Allis Chalmers Co. is 84 %. Each wheel is direct-coupled to a 2-phase, 60-∿, 2300-volt, vertical-shaft generator. Two 125-volt, 100-kw. exciter sets, compound wound, with inter-poles, are driven by 150-h.p. induction motors at 1200 revs. per min. At the steam station a small double-throw switch will start the automatic control at the hydroelectric plant, placing a machine on the line without further attention. It is arranged that normally the water-driven plant will be loaded up to the full capacity the water flow allows and the load variation will be dealt with by the steam plant. A lowering of the water head automatically cuts generators off the line in a certain sequence, and, conversely, with a rising head machines will start up and come in on the line. Any trouble cuts the machine or machines out. The generator fields are always excited, so it is possible to use a partially-loaded set to improve the power-factor of the system. Each machine, with its water-wheel and gate-opening controlled by motor, control relays and contactors forms a complete separate unit, except for field excitation. There are no instruments at the hydroelectric station: all these are at the steam station; the connection between them is by three groups of conductors, namely, the power cables, instrument cable, and control cable. Excess-speed protection is afforded by a 1-h.p. induction motor continuously on the line, driving a speed-limit device which will close a circuit through a relay when the speed reaches the given limit. Details of the operation of the switchgear, which is of standard pattern, are explained. A list of 48 conditions which might cause trouble, including short-circuiting and exciter failure, was made, and each of these conditions was applied to test the apparatus. In every case the plant or machine was automatically shut down as required until normal conditions were restored. W. N. Y. K.

211. *Gas-engine Central Station at Zollverein Pit.* **H. Wiegleb.** (Techn. Blätter, Nos. 33 and 34, 1917. Elektrot. u. Maschinenbau, 35. p. 557, Nov. 18, 1917. Abstract.)—Since 120 new coke-ovens had to be installed at the same time as a central station for 5000 kw. the opportunity was taken to utilise gas obtained from the new ovens. The quantity of gas is 5700 m.³ per hr.; lower calorific value 4000 kg.-cals. In gas engines consuming 3800 kg.-cals. per kw.-hr., this suffices for 6000 kw. Using the gas to heat the boilers of a turbine plant the obtainable output would be 3600 kw. The higher cost of the gas-engine plant is justified. Three twin-tandem engines, each of 3000 kw., were installed; one being in reserve. Room is provided also for a single-tandem 1500-kw. engine. The main floor-level of the engine-room is such that railway wagons could run right in during building. Pipes, cables, compressed air and lubricating oil tanks are in the basement. Circulating water pumps, main gas pipes, ignition accumulators, transformers, and switchgear are in an annexe. Purifiers, regenerators, coolers, and gasometer are near-by, so that long pipe lines are avoided. Tar and sulphur are removed by a dry-cleansing process; the purifying material is regenerated from time to time.

The engines are double-acting four-stroke machines; cylinder diam. 1150 mm., stroke 1800 mm., 94 r.p.m.; max. continuous output 4500 h.p. A new arrangement of valves is embodied, reducing the risk of breakages. The governor operates simultaneously on gas and air supplies, and is effective even with 60 % to 70 % load variations such as are encountered frequently

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during electric winding. The cooling water plant is designed for 9000 kw. with a margin to cover extensions. Two cooling towers provide for 850 m.³ per hr. There are three centrifugal circulating pumps (each 425 m.³ per hr. ; one in reserve) serving the cooling towers and a similar set supplies cooled water to the engines. An elevated water tank of 150 m.³ capacity is for equalising and reserve purposes. R. E. N.

212. *Electrification of the Savona-Ceva (Italy) Mountain Railway.* **W. Lesniewski.** (El. Rly. J. 50. pp. 1150–1158, Dec. 29, 1917.)—The electrified section is 28 miles long with single track and a number of tunnels and curves. The max. gradient is 1 in 40. Between Savona and Ferrania there is a very difficult section, in which the elevation of the track varies more than 1000 ft. within a distance of 10 miles. The 3-phase system is used with 3700 volts for the contact line, and a frequency of 16·7. The speed on the steepest ascent is 31 miles/hr., whereas specially powerful steam locomotives of the "decapod" type were unable to exceed 15 miles/hr. The express trains are limited to 30 miles/hr., as more powerful locomotives, which were to have been worked on the regenerative system, have not yet been delivered. Pusher locomotives are used on the heavy gradients: the traffic on the line has greatly increased, and the time for the 28-mile trip has been reduced by 20 mins. The rail bonds are made of soft iron, and meet the needs in conductivity; they are very solid and cheap and unlikely to be stolen. The line has been open since 1914: the Savona end is on the Gulf of Genoa.

W. H. S.

213. *Otis Passenger Elevator at Inspiration Shaft.* **C. E. Arnold.** (Am. Inst. Mining Eng., Bull. No. 132. pp. 2019–2028, Dec., 1917.)—The authors recommend the application of elevator practice in high commercial buildings to the hoisting of men in mine shafts. At the mine and mill plant of the Inspiration Consolidated Copper Co. the elevator cage runs in a concrete-lined shaft 5 ft. 11 in. by 5 ft. 6 in. in section and 585 ft. deep; the counterweight runs in the pipe and ladder compartment of a twin shaft 102 ft. distant. The hoist will carry 7500 lbs., exclusive of cage, weighing 7500 lbs. at a max. speed of 800 ft. per min. It is driven by a 160-h.p. direct-current motor served by a 190-h.p. motor-generator. The controller magnets, brake and fields of the hoist motor and generator are supplied by a small d.c. generator on the motor-generator shaft. The drum, 72 in. in diam., is driven through single-reduction herring-bone gear and flexible coupling. Cage and counterweight cables are 18 in. diam. The cage carries 36 mm., 16 on the upper deck, and 20 on the lower. Safety devices are provided in the shape of solenoid brake, gate switches, limit, emergency and slack cable switches, buffers, stop-motion controller and wedge clamp; the latter operates to check the speed of the cage in an emergency. The time of winding through 847 ft. is 2 min. 59 secs., divided as follows: lowering, 45 secs.; discharging and lowering 36 men at 4th level, 45 secs.; hoisting, 44 secs.; discharging and loading 36 men at surface, 45 secs. The 1000 men at the mine are handled daily by the elevator, which requires 480 units per day. W. E. W.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

214. *Electric Traction with Accumulators.* **F. Rossi.** (Elettrotecnica, 5. pp. 2–5, Jan. 1, 1918.)—The development of the electric traction with accu-

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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mulators has been considerably hindered in Italy by two experiments made about 15 years ago, one between Milan and Monza and the other between Bologna and San Felice. The results of these experiments were not satisfactory. Hence a cloud of suspicion remained over this form of traction, in spite of the considerable advances in the construction of the accumulators.

The author demonstrates that in the following cases this system of traction is preferable to any other: (1) For short, flat lines with limited traffic and for local services; (2) for shunting services in stations and for connecting these with industrial works.

The economic side of the matter is developed for two concrete cases: in the first case the cost would be 24 % less than if steam traction were adopted, in the second case 30 %.

Some views of accumulator locomotives adopted by some industries and harbours illustrate the article. E. B.

215. *Experiences with Interurban Car Axles.* **A. B. Metcalf.** (El. Rly. J. 51. p. 94, Jan. 12, 1918.)—On the lines of the Beebe System, of which this railway formerly was a part, a number of different grades of material have been tried for car axles, with varying results. Until the last year or two all axle defects occurred at a point between the hub of the gear and the hub of the wheel on the gear end of the axle. The gear was mounted close to the wheel. To reinforce the axle at the weak point the diam. of the wheel fit was increased from 6 in. to 7 in. As the gear seat was originally 7 in. this made the axle 7 in. in diam. at the point where practically all the cracks had developed. Not one of the axles having a 7-in. diam. wheel and gear fit has developed cracks at this point, which tends to prove that the previous axles were weak here. Cracks developed at the other end close to and inside the wheel hub. Originally the cars were equipped with open-hearth untreated steel axles, most of which developed cracks in the first 250,000 miles, but others are still in service. Some of these have made between 600,000 and 700,000 miles. Carbon-steel axles were next tried, but these were found at first to be too hard and gave trouble in less than 100,000 miles. Lower carbon steel has given very good service. Low-carbon and nickel-steel axles, specially treated, proved very soft with a low elastic limit, and gave very low mileage before developing defects requiring them to be discarded. The axles which have given the best results are of vanadium steel, with wheel and gear fit 1 in. larger in diam. than the main body of the axle. The method of inspection is to take a very fine cut with a sharp lathe tool over the section where the crack is liable to develop, and if the axle has the least crack in it the operator can see it with a naked eye. It is recommended that a test-piece should be taken from each end of each axle made, and that a report of a test made by the manufacturer should be furnished to the customer. C. E. A.

216. *Batteries on Electric Vehicles.* **K. Rutherford.** (El. Rev., Chicago, 71. pp. 717–719, Oct. 27, 1917.)—The author points out the desirability of providing good thermal insulation round the batteries on electric vehicles so as to maintain the capacity during cold weather, especially in the case of Edison cells. He states further that the battery box might with advantage contain a small electric heater of about 100 watts. W. R. C.

ELECTRIC LAMPS AND LIGHTING.

217. *Further Investigations with Arcs under Pressure.* **W. Mathiesen.** (Elekt. Zeits. 38. pp. 573–575, Dec. 6, 1917.)—Whereas the former experiments

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[Abs. 150 (1917)] were made with arcs operated in air under pressure, the present series relate to arcs in oxygen and nitrogen under pressure and to arcs burning in their own gaseous products. I. *Arcs in Oxygen.*—The atmosphere in the test vessel was kept as nearly as possible pure oxygen. Pure carbons were used, the positive (Noris cored 10 mm.) being horizontal, and the negative (solid 9 mm.) being set at an obtuse angle. At constant voltage (42 volts) the arc became shorter as the gas became very unstable. On the other hand, the arc burned very steadily when the gas pressure was 40 cm. Hg (abs.). The carbon tips become incandescent for a relatively great distance, and continue to burn after the circuit is broken (for 11 mins. at atmospheric pressure, and 25 mins. at 2 atmos. abs.). The negative cone gradually extends back about 6 cm., and becomes almost needle sharp at the point. At 8 atmos. abs. the carbon consumption was 28 gm. positive and 14 gm. negative per hr., *i.e.* 87 gm. total, compared with 9 gm./hr. in air at 8 atmos. The appearance of the arc and of the relatively large flame is illustrated in the original. The c.p. of the arc with increasing gas pressure varies irregularly [Table I, line (*a*)], but these data were confirmed by a fresh series of measurements. A constant-voltage series of tests in air showed steady increase in candle-power [see Table (*b*)], but only to a moderate degree, the arc being short.

	Candle-power (Hefner) at atmos. (abs.).				
	½.	1.	2.	3.	4.
(*a*) Arc in oxygen ; 10 amps. 42 volts	—	540	900	600	700
(*b*) Arc in air ; 10 amps. 60 volts	—	1990	2150	2250	2400
(*c*) Arc in nitrogen ; 10 amps. 60 volts	1600	2100	2200	2050	2200

The low c.p. of the arc in oxygen is not due to any appreciable difference in the intrinsic brilliance of the crater, but is due partly to the great obliquity of the latter and its consequently reduced projection, and partly to an actual reduction of the positive crater area consequent upon the intensive combustion of the carbon in oxygen. Ionisation occurs to such an extent that the dark discharge (considered as a shunt to the arc) absorbs a certain amount of current and reduces the crater area correspondingly.

II. *Arcs in Nitrogen.*—The arc is considerably steadier in nitrogen under pressure than in air. There is practically no combustion ; hence the conductivity phenomena are attributable solely to electrical causes. The appearance of the arc is practically the same as in oxygen or air, save that the core is very weakly luminous. The candle-power varies little with the gas pressure (see Table (*c*)). It is not considered that absorption of light by NO_2 was responsible for the low c.p. at reduced pressure. A steady stream of gas was maintained through the arc chamber, and there was no smell of NO_2 in the escaping gas. The author discusses possible causes of a curious luminous green crown or halo noticed round the tip of the negative carbon at 8 or 4 atmos. and at 40 cm. Hg but not at 1 or 2 atmos. (abs.). Possibly it is the luminous fringe of a dark discharge. The carbons burned to the same shape as in air ; this could not be due to a small proportion of oxygen, since carbons

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burnt in CO_2 similarly introduced kept quite blunt ends. Possibly there is formation of CN, not only in the arc but also at the glowing tips of the carbons. This would cause carbon consumption (much less than in air) and hence the observed formation of the tips. Electrochemical formation of CN may also explain the luminous halo which is visible only round the negative, where the pointing of the carbon is greater.

III. *Arcs in their own gaseous products.*—Stockhausen says that the gaseous products of an arc burning under normal pressure are: H, CO, CO_2, N, marsh gas, and traces of oxygen. In addition, there are vapours from impregnating materials when the latter are used, and NO_2 in the case of arcs burning under pressure. The author used a yellow-flame Excello (calcium fluoride, 104) positive carbon and a solid Noris negative; 10 amps., 55 volts. The air pressure was 5 atmos. (abs.) to begin with, and decreased by leakage to 4·5 atmos. (abs.) at the end of 87 min. The initial c.p. was 4150 hefners; this fell to 1700 hefners in 10 mins.; 1100 hefners, 20 mins.; 890 hefners, 80 mins.; 890 hefners, 87 mins. The oxygen initially present would, of course, be consumed rapidly at first and then ever more slowly. The fall in pressure of the gases might account for 20 % decrease in c.p., but even allowing for this the c.p. fell from 3820 to 890 hefners in 87 mins. Comparison with an arc between Noris cored and Noris solid carbons (1840 to 1300 hefners in 81 mins.) indicated that the great decrease in the figures for the flame arc was probably due to absorption by vapours from the calcium fluoride as well as (possibly) to the formation of considerable quantities of NO_2.

In air, in oxygen, and in nitrogen (but to different degrees), there occurs an increase in arc c.p. with increasing gas pressure, the consumption of electrical energy being kept constant. R. E. N.

218. *Electric Glow-lamps.* **A. Boutaric.** (Rev. Gén. d'Él. 1. pp. 848–852, June 2; 931–941, June 16, and pp. 972–979, June 23, 1917.)—The author presents, in a form convenient for reference, a summary of the properties of the various metal filament lamps. L. H. W.

219. *Siemens and Halske Globe Photometer.* **R. v. Voss.** (Elekt. Zeits. 38. pp. 605–606, Dec. 27, 1917.)—Describes further measurements, on lamps of different light distributions, with the globe photometer previously described [see Abs. 478 (1917)]. J. W. T. W.

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TELEGRAPHY AND TELEPHONY.

220. *Electrical Determination of Ore Beds.* (U.S. Pat. 1,240,328. El. World, 70. p. 1287, Dec. 29, 1917. Abstract.)—R. A. Fessenden describes in his specification a method by which he has detected and located a body of mineral at a distance of 2½ miles. Holes are drilled in the earth, these being then filled with water into which sending and receiving apparatus is lowered. In the above case four holes might be bored 5 miles apart, and the apparatus used would be 8 photo-recording Einthoven oscillographs, coupled to microphone receivers, and a single strong underwater sound-wave oscillator, such as is used for submarine signalling. The time is noted that is taken by sound to travel between two points a known distance apart. Thence conclusions may be drawn concerning the probable nature of rock between the two points. If an echo or refraction of sound be noted, it is possible to estimate the distance of the reflecting or refracting vein. R. E. N.

221. *Distributed Inductance of Vertical Grounded Antennæ.* **A. Press.** (Inst. Radio Eng., Proc. 5. pp. 413–416, Dec., 1917.)—In calculating the inductance of a vertical antenna, it is usually assumed that the capacity and inductance are uniformly distributed along the wires. The present paper deals with the calculation of the inductance when the *current* is uniformly distributed along the antenna. The formula obtained for the inductance per unit length at a distance x from the base of the antenna is $Lx = 2 \times 10^9 \log_e(4x/d)$, where d is the diam. of the antenna wire.

N. W. M.

222. *Phenomena in Resonance Transformer Circuits.* **H. Yagi.** (Inst. Radio Eng., Proc. 5. pp. 433–446, Dec., 1917.)—A mathematical paper in which the effect of the superposition of the transients produced by successive condenser discharges is considered. Two cases are investigated: (1) Alternate discharge, in which there is one spark per half-cycle; (2) unidirectional discharge, in which there is one spark per cycle. Expressions obtained for the condenser e.m.f.'s show that, in both cases, the variation therein can be represented by the superposition of a sustained oscillation of the same frequency as the alternator, and a damped oscillation of the natural frequency of the secondary circuit of the transformer. For efficient working, the rise of condenser e.m.f. e_2, before a discharge should be rapid, that is, $(de_2/dt)_{t=\pi/\omega}$ must be large (ω= forced frequency or frequency of alternator), and the rise of e_2 after a discharge should be slow, or $(de_2/dt)_{t=0}$ be small. In order to approximate to these conditions, which are theoretically inconsistent, the ratio of the natural to the forced frequency (β/ω), must be adjusted.

The effect of varying the ratio β/ω is considered with reference to steady sparking, and to the possibility of operating transformers at the absolute resonance point, namely, $\beta/\omega = 1$. Curves showing the relations between $\beta\omega$ and other quantities involved in the mathematical analysis, are given for the two types of condenser discharge. N. W. M.

223. *Relation of the Audibility Factor of a Shunted Telephone to the Antenna Current.* **G. W. O. Howe.** (Phil. Mag. 35. pp. 181–188, Jan., 1918.)—Discusses the results recently obtained by van der Pol [Abs. 746 (1917)]. It

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appears that if the impedance of the telephones is three or four times their d.c. resistance, the results obtained by van der Pol would be considerably modified, and the audibility factor would appear to vary as a higher power than the square of the radio-frequency current. This, however, is improbable.

In a note by **van der Pol** (*ibid.* pp. 184–185) he points out the fact that it is by no means clear whether Austin or Hogan employed the true impedance of their telephones in the audibility factor, as in their papers no references are given as to how these impedances were determined. Further, it is a matter of considerable difficulty to measure the true impedance of a telephone as ordinarily used in series with a crystal detector, and hence it is suggested that it is better to use the steady resistance, so as to avoid assumptions as to the ratio of impedance to resistance. A. W.

224. *Manufacture of Vacuum Detectors.* **O. B. Moorhead.** (Inst. Radio Eng., Proc. 5. pp. 427–480; Disc., 481–482, Dec., 1917.)—Describes in detail the method of manufacture of vacuum detectors, with special regard to expense, efficiency, and accurate reproduction of a definite type. Various grades of glass were experimented with, and a mixture containing a high percentage of lead and a small quantity of silicic acid was found to be the easiest to work, and produced a detector of max. sensitiveness when used in conjunction with an Al plate and a copper grid. Other metals besides tungsten were tried as filaments, and showed widely different operating characteristics. Special treatment has to be given to the Al and copper used in the detectors, as materials purchased from different sources gave altogether different results. The Al employed was subjected to a temperature of approximately 600° F., then immersed in a saturated solution of potassium cyanide, and finally rinsed in alcohol. The copper was heated till it glowed, and the resulting oxide being scaled off left a clean metal surface. The copper was then placed in a current of moist air, when it becomes covered with a thin layer of oxide. This method of treatment eliminated variation to a considerable extent. In the process of evacuation, a number of tubes are sealed to the pump manifold, and the temperature is raised to 900° F., when the pumps are started. When the vacuum has reached one micron, the temperature is gradually increased to 1000° F., the tubes being carefully watched to avoid collapse due to softening of the glass. The vacuum slowly increases, and after about five hours' pumping the tubes are sealed off and allowed to cool in the oven. An induction coil is used to test the vacuum, which is such as to permit a 5-in. spark between needle-points in air without showing a glow in the tubes joined to the manifold.

Richardson has shown that new metals, when heated to incandescence, emit positive ions. This emission must be eliminated to obtain max. sensitiveness of the detector, and this is accomplished in the manufacturing stage by heating the filament on alternating current for about two hours. A. W.

225. *Direct-reading Damping Meter.* **H. Wiesent.** (Jahrb. d. Drahtl. Tele. 12. pp. 330–349, Dec., 1917. Abstract of Dissertation, Munich).—The full paper corresponding to Abs. 482 (1917).

226. *Experiments with Long Electrical Conductors.* **J. H. Morecroft.** (Inst. Radio Eng., Proc. 5. pp. 389–411; Disc., 412, Dec., 1917.)—By the term "long electrical conductor" is meant one on which an appreciable portion of a wave-length is developed. In this paper conductors are considered that have lengths from 1/4 to 1/20 of the wave-length at the impressed frequency. Short conductors may also be distinguished from

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long ones by the consideration that in a short conductor the current is practically the same throughout its length, whereas in a long one the current varies throughout the length. The distributed resistance, reactance, and capacity of the long conductors were imitated by making an artificial line with 9 sections, each containing an air coil of resistance R (0·702 ohm.) and coefficient of self-induction L (0·0415 henry), and a capacity K made up of various numbers of condensers of 0·915 mfd. each, 400 of these condensers being used in some of the tests. The line approximated sufficiently nearly to one with distributed reactance and capacity, as there were in most of the tests more than 25 sections per wave-length, and it is known that 6 sections per wave-length is a sufficient distribution to give results closely approximating to the theory. The constants of the line were measured by voltmeter, ammeter, and wattmeter, and with $L = 0{\cdot}0415$, $R = 0{\cdot}702$, and $K = 86{\cdot}6$ mfd. For frequencies between 12 and 152 cycles per sec. the impedance assumed values between 165 positive ohms (reactance), and 165 negative ohms (capacitance), and the phase angle between the voltage and current changed periodically between 75° lead and 75° lag. The resonant frequencies were obtained at all the multiples of the fundamental frequency of 22·8 cycles per sec. Tests were also made with standing waves, the open-circuited line being tested at frequencies for which the wave-lengths were 4 times and multiples of 4 times the length of the line. The voltages at points along the line are plotted, and these did not become quite zero at the nodes. This is due to the fact that owing to the losses in the line the voltage at the nodes must suffice to carry the energy required to maintain the line in a state of oscillation.

The conditions existing in an antenna were imitated by adding capacity or inductance at the beginning of the artificial line, and voltage and current distributions are plotted for a number of cases. The case of the T-antenna is also examined. In connection with the meaning of the inductance and capacity of an antenna, as usually measured, three lines were tested containing the reactances L as above and capacities of 86·6, 9·15 and 1·85 mfd. per section respectively. In each case the measured frequencies giving quarter wave-length oscillations were found to have values about 68·6 % of the calculated quarter wave-lengths using the formula $1/[2\pi\sqrt{(L\,K)}]$, in which L and K are the *total* inductance and capacity. This follows from the fact that the average of a sine wave is 68·6 % of the max. value when taken over 1/4 period, and on this account the effective self-induction and capacity have values 68·6 % of the total values. When the line was loaded with series reactance of varying amounts it had varying effective lengths, and the effective self-induction and capacity were obtained as averages of sine waves taken over decreasing fractions of 1/4 of a period as the loading reactance was increased. The effective capacity varied between 68·6 % and 100 % of total capacity, and the effective reactance between 68·6 % and 50 % of the total reactance as the loading reactance was increased. In examination of the effective resistance r and actual resistance R of the line, it is shown that for the open line the current distribution follows a sine law and the effective value of the current is 0·707 I, where I is the current at the beginning of the line, and on this account $R = (0{\cdot}707)^2 r = 0{\cdot}5\,r$; as the loading is increased the current distribution tends towards a straight line instead of a sine law and the effective current becomes $I/\sqrt{3}$, so that R tends towards the value $r/3$.

The measurements of antenna constants as usually made are more or

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less meaningless, as these constants depend on the frequency with which the antenna is oscillating. In the *discussion*, **A. E. Kennelly** pointed out that the experiments indicated interesting methods for deducing the phenomena in an antenna oscillating during a cycle of a few micro-secs. from observations of the phenomena in steady oscillations on the low-frequency artificial line. The one difficulty lay in the imitation of the radiation resistance. A. J. M.

227. *Artificial Telephone Lines.* **J. B. Pomey.** (Rev. Gén. d'Él. 8. pp. 123–125, Jan. 26, 1918.)—The author points out that the H-connections used by Breisig to imitate a telephone line by means of a single element are not by any means the only suitable arrangement. He shows by the application of the Kirchhoff equations to a generalised network of any number of meshes that the necessary relations between the conditions at the "in" and the "out" terminals always exist. He investigates the particular case of a single quadrilateral mesh, the "in" terminals being placed at the ends of one diagonal and the "out" terminals at the ends of the other, and shows that this arrangement, which is not more complicated than the H element, satisfies the conditions and can easily be arranged to imitate any homogeneous or non-homogeneous line. W. H. G.

228. *Calculation of Telephone Transformers.* **R. Holm.** (Archiv f. Elektrot. 6. pp. 118–138, 1917.)—Formulæ for determining optimum values for the primary self-induction and the ratio of the number of turns in order to secure the max. transference of energy from one telephone circuit (line or transmitting instrument) to another (line, receiving instrument, amplifier) are developed, in the first place for transference in one direction only, and secondly for both directions. Breisig, in his "Theoretische Telegraphie," has given solutions for simplified conditions; the present author takes into account complex values of the impedances of the circuits to be connected, dispersion, winding capacity, and iron losses and his formulæ permit not only the determination of the optimum conditions but also that of the efficiency attained and the effect upon it of departures from the said conditions. This effect is examined by means of numerical examples, which show that as a general rule large departures may be made without serious effect on the efficiency. The actions of winding capacity, iron losses, and dispersion are examined in turn. The method of taking account of these, and of the iron losses, in particular, is of interest. For the winding capacity the methods and results of Rietz [Abs. 1495A (1918)] are used. The original paper should be referred to for the method of treatment and the conclusions. It appears that in most practical cases, where the impedances are not widely different from one another, the formulæ for Breisig's simplified case may be applied with confidence to the practical conditions. W. H. G.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

APRIL 1918.

PRIME MOVERS.

STEAM PLANT.

229. *Heat Engines.* **H. R. Sankey.** (Inst. Mech. Eng., J. No. 1. pp. 708–749, Jan.; Disc., 795–809, Feb., 1918. Thomas Hawksley Lecture.)—A summary of progress to date; a few remarks on future developments are given in conclusion. The lecturer states that "From the power lines it would seem that both gas- and oil-engines have reached a practical limit as to size, but the steam-turbine can, it appears, be built in larger units than any yet attempted—a view which is confirmed by considerations of initial cost, space occupied, and facilities of manufacture, erection, maintenance, and running. It will also be observed that even now the power developed by the largest steam turbine is over twelve times greater than that of the largest internal-combustion engine. Notwithstanding, therefore, the considerably higher heat economy of gas- and oil-engines as compared with steam-turbines, the last will hold the field for the large units used for electrical power distribution until a satisfactory gas-turbine has been evolved.

There has been much theorising on the subject of gas-turbines during the last fifteen years, and a few small experimental turbines have been built, but so far there has been no real progress. The main difficulty is to obtain a material for the blading that will withstand the very high temperatures of the impinging gas. There is also the loss due to compressing the combustible mixture of gas and air, which loss greatly reduces the intrinsic higher thermal efficiency of the internal-combustion engine, so that, under the best conditions, it is not likely that the brake thermal efficiency of a gas-turbine will much exceed that of the present steam-turbine. For reasons which would take too long to explain, an experimental gas-turbine must be of very large size, hence the experiments would entail heavy expenditure, and it is hardly to be expected that private enterprise would be justified in risking the great expenditure involved." L. H. W.

230. *The Lubrication of Steam Turbines.* (Power, 47. pp. 198–201, Feb. 5, 1918.)—Gives a general summary of the conditions obtaining in the lubrication of steam turbines and describes different lubricating systems. Oil

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consumption for turbines is more than for any other prime mover, owing chiefly to leakage and evaporation. The bearings on either side of the turbine are subject to radiated heat from the steam. Lubrication is effected either by ring oilers or by some form of circulating system. Ring oilers are satisfactory if free from vibration and sharp edges, and where the reservoir is of ample capacity. A self-contained circulating system for larger turbines is shown in a diagram. There are several places where water finds its way into the oil, chiefly at the high-pressure end packing gland; and when turbines work on back pressure, steam leaks at the exhaust and gland. On account of the oil and hot water forming an emulsion it is generally necessary to provide some means other than only a filter screen to separate the water and oil. One method is a separate filter: then more oil is in circulation and there is more chance for the separation of oil and water. Many mechanical difficulties were experienced with low-viscosity oils, and the majority of turbines can best be lubricated by a medium oil. Instructions concerning lubrication by the Terry Steam Turbine Co., the Westinghouse Machine Co., and the Allis-Chalmers Manufacturing Co. are quoted. The oil should be pure mineral oil free from acid. Animal fats decompose, forming acids that corrode the shaft and bearing metal. W. N. Y. K.

231. *Condensers with Seventy-foot Water-level Variation.* **F. R. Brosius.** (Power, 47. pp. 142–144, Jan. 29, 1918.)—The West End power station of the Union Gas and Electric Co., Cincinnati, Ohio, is situated on the north bank of the Ohio River, which rises and falls about 70 ft. To supply condensing water at all states of the river involved special arrangements, and the construction used is that of concrete wells, five in number, comprising an intake well in the centre with a condenser well and discharge well on either side. The intake well is 86 ft. deep × 60 ft. inside diam., the walls are solid reinforced concrete 6 ft. thick. The intake tunnel leading from the river-bed is 163 ft. long × 25 ft. high × 10 ft. wide, with reinforced concrete walls 2 ft. 6 in. thick. The condenser wells are each 68 ft. inside diam. and 84 ft. deep. The floors are 16 ft. thick at the walls and 30 ft. thick at the centre, and the walls are 8 ft. thick. The west condenser well is used for the initial installation of two 25,000-kw. turbo-generators, and contains all the condensing equipment for the two turbines which exhaust through pipes 13 ft. in diam. and 62 ft. long into vertical condensers, each with 52,000 sq. ft. of cooling surface. The discharge wells are 17 ft. inside diam. with walls 3 ft. thick. Two discharge pipes enter the discharge well and are sealed into the end of the branch of the discharge tunnel. The branches are 6 × 10 ft., meeting to form a single tunnel 10 × 10 ft., with walls 2 ft. 6 in. thick, extending 214 ft. downstream. The water system is a closed siphon. The larger wells were constructed by building a circular section and excavating under it to allow it to sink by its own weight. Part of the weight of the turbine-room is taken by the wells.

Plans, sectional elevations, and views show the construction. W. N. Y. K.

232. *Reduction of Fuel Costs and Boiler-maintenance Charges.* **S. B. Applebaum.** (El. World, 71. pp. 349–352, Feb. 16, 1918.)—This article deals with the losses due to scale, and describes the two main types of water-softening apparatus. As regards the losses due to scale, experiments made at Illinois University Engineering Station between 1898 and 1908 with a locomotive type of boiler and with individual tubes proved that a scale of 1·19 mm. thickness (3/64 in.) caused a loss of efficiency equivalent to 9·6 %

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in the former, and that scales up to 9·175 mm. in thickness (1/8 in.) caused losses up to 12 % in the latter, according to the physical structure of the scale. The water-softening apparatus described is classified under two general types: (1) the lime-soda type, and (2) the exchange silicate type. The latter produces a water of zero degrees of hardness when properly worked, since all the lime and magnesia are removed from the water and replaced by soda. Some waters are most economically treated by a combination of the two methods, namely, waters showing a high amount of temporary hardness, which can be reduced by simple treatment with caustic lime. With waters of high permanent hardness, however, there is no advantage in the combination process, because soda-ash works by exchange on the permanent hardness, as the exchange silicates do. Further, about 3 to 4 lbs. (1·36 to 1·82 kg.) of salt is needed for regeneration as against 1 lb. (0·45 kg.) of soda-ash. With salt at ¼ cent per lb. and soda-ash at 3 cents per lb. the comparative cost of removing permanent hardness by the two processes would be 1¼ cents for the exchange silicate and 3 cents for the soda-ash. J. B. C. K.

GAS, OIL AND WATER ENGINES.

233. *A Volume Regulator for Blast-furnace Gas Engines.* **L. C Lowenstein.** (Am. Soc. Mech. Eng., J. 40. pp. 224–233, March, 1918. Abstract.)—Treats of the blast-furnace as a pig-iron producer and as a gas-producer. If the charging of a furnace is uniform the quantity of air supplied should also be uniform. The air pressure required to effect this varies with the condition of the charge from, say, 10 lbs. to 30 lbs., therefore the air compressor should adapt itself automatically to supply a predetermined weight of air according to the amount of charge in the furnace, independently of the resistance. Only two of the various methods for measuring the quantity of air supplied are used commercially for regulating the supply of air to blast-furnaces, namely, the Venturi meter and the impact float. A centrifugal compressor can be very finely regulated, as it delivers a steady stream of air without pulsation, and the pressure varies as the square of the speed. In order to reduce power loss a multiple Venturi meter has been devised, consisting of a number of concentric venturis. The largest pressure drop is obtained at the throat of the smallest venturi. With a triple venturi passing 45,000 cub. ft. per min. of standard air the calculated drop at the inner venturi is 7·28 in. Hg (3·57 lbs. per sq. in.). The loss of power is 0·18 h.p. for the inner, 1·06 h.p. for the middle, and 31·38 h.p. for the outer venturi, *i.e.* the total loss is 32·62 h.p. The working and construction of the following apparatus is described and illustrated: A constant-volume governor, with U-tube and quantity scale: An impact-float governor, and volume-corrector for the same, for air of any temperature, barometer or humidity. W. N. Y. K.

234. *The Flugel Pressure Reduction Valve.* (Automotor J. 23. pp. 119–120, Feb. 15, 1918.)—This is a reduction valve adapted for use with gas containers working at 7 to 10 atmos. on motor vehicles. It is of the spring-controlled diaphragm type with the valve in the form of a small fibre-ended plug connected to the diaphragm through a knuckle joint. Between the high-pressure gas-container and the reducing valve there is a gas filter composed of metal gauze and felt. The complete apparatus also comprises shut-off and safety valves arranged on the high-pressure side of the diaphragm, and on the low-

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pressure side an expansion chamber which enables a reserve of low-pressure gas to be provided for starting or for variation in throttle opening. C. A.

235. *Crankshaft Design.* **O. M. Burkhardt.** (Am. Soc. Mech. Eng., J. 40. pp. 212–219, March, 1918. Abs. of paper read at meeting of Eng. Soc. of Buffalo, Oct., 1917.)—Discusses the problems arising in the design of crankshafts for 6- and 12-cylinder engines. The paper includes diagrams showing the forces on crankshafts and crankpins at various parts of the engine cycle. It is concluded that, as is generally the case in practice, the 12-cylinder engine may run at a slightly higher speed than the 6-cylinder engine, and its bearings should be designed to give at least 15 % more bearing surface. A factor of safety of 12 for the crankpin is considered not excessive for such an important part. On this assumption dimensions are calculated for crankpins and crank cheeks for a given engine. The explosive impulse of a 6-cylinder engine may be 1·5 times as large as that in a 12-cylinder engine of equal total piston displacement. J. W. T. W.

236. *Model Strength Tests for Aeroplane Structures.* **W. L. Cowley and H. Levy.** (Engineering, 105. pp. 219–220, March 1, 1918.)—Discusses the theory of model strength tests by applying the principle of dimensional homogeneity between model and full-size structures. Let the length of one part, say a bay, be given by l, the area of a particular section by A, moment of inertia I, and the elasticity and density of the material of which it is composed E and ρ respectively. Given these quantities for one portion it will be assumed that the shape and geometry of the structure involve an exact specification of how to derive the corresponding quantities for the remaining portions. Let the external load be F, applied in some manner specified by the geometry, and suppose that this is sufficient to produce a stress just greater than the yield stress f in the material of the weakest member. F can only depend on the geometry and the manner of application of the quantities enumerated above. From a consideration of the dimensions of these it is shown that $F \propto E^x A^y I^z l^p \rho^q f^r g^s$. Equating the dimensions of this to the dimensions of F, *viz.* MLT^{-2}, it is found that F may be written $F = (EI/l^n)\psi[(f/E), (A/l^n), (W/fA), (I/l^4)]$, where ψ is an arbitrary function. Writing $\phi^2 = Fl^n/EI$ then $\phi^2 = \psi$. For a given structure where l, E, and I are known ϕ is uniquely determined, so that the discussion of collapse by rupture may be centred round ϕ. For a series of which all members are identical in shape, A/l^n and I/l^4 are constants, so that $\phi^2 = \psi_1[(f/E), (W/fA)]$. Of these two quantities the former may be taken as the strain at the yield-point, on the assumption that Hooke's law holds rigorously over the whole range, and the second is the ratio of the weight of a particular member, say the weakest, to the max. tensile or compressive force which that member is capable of withstanding. If the model and the full-scale structure be made of the same materials in corresponding parts, f/E is a constant and W/fA is proportional to the linear dimension l. The breaking load coefficient ϕ^2, therefore, is purely a function of l, and the form of the function is determined only by the shape of the various parts, the geometry of the loading and the so-called geometry of the material. It is pointed out that a possible source of invalidity of the above reasoning is the failure of Hooke's law, but exactly the same trouble would arise in a mathematical investigation of the stresses brought into play. J. W. T. W.

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PROPERTIES OF ENGINEERING MATERIALS.

237. *Ferrochrome and Ferrocobalt.* (U.S. Pats. 1,245,552 and 1,247,206. Met. and Chem. Eng. 18. p. 208, Feb. 15, 1918. Abstract.)—F. M. Becket describes two new alloys. The ferrochrome contains 25 to 80 % Cr, 1·5 to 8 C and 0 to 8 Si; the alloys are very tough and hard and resist oxidation, especially when rich in Si, which turns them brittle, however; they are fibrous, can be forged, annealed, tempered, machined, and are useful also as abrasives, for turbine plates, cutting tools; one alloy was not appreciably corroded by being kept in an oxidising atmosphere at 1100° C. for two weeks. The other alloy is a ferrocobalt, approximately Fe_2Co, with 2 to 6 % Si; the hysteresis value is low and the magnetic saturation high, especially with high Si content; the carbon percentage should be kept as low as possible. H. B.

238. *Parker Rust-proofing Process.* (U.S. Pats. 1,254,268 and 1,254,264. Met. and Chem. Eng. 18. pp. 264–265, March 1, 1918. Abstract.)—The Parker Rust-proof Co., of Detroit, treats all kinds of iron and steel, dental needles as well as big structural pieces of 20 ft., in the same bath by processes patented to W. I. Oeschger. The metal is first cleaned by sandblast, pickling, or in soda lye, and then immersed in an acid metaphosphate bath, which contains tungsten or molybdenum or simply black iron scale Fe_3O_4. The scale is powdered and stirred with phosphoric acid and water to a paste which is dried and powdered; the other metals are added as oxides or carbonates; in order to impart to high-carbon steels a hard surface the tungsten, etc., may be replaced by 2 % of strontium. The metals to be treated are immersed in the boiling phosphate bath, when they turn soft grey: they are then coated with a special oil to obtain a black matt finish; articles to be painted are not oiled. According to the second patent the iron is heated to 600° F. and exposed to the fumes of the heated metaphosphate; this treatment may take place in the furnace. The rust-proof iron will not stand acids (sulphuric, hydrochloric, acetic), nor continuous exposure to chemical fumes. The process is said to be much cheaper than the original process used in England; there are works in Detroit, and other plants are to be established. H. B.

239. *The Science of preparing Axle Steel.* **W. L. Allen.** (El. Rly. J. 50. pp. 989–992, Dec. 1, 1917.)—The author describes the cause of failure of car axles under static and dynamic stresses and points out the necessity of removing stresses set up by forging and irregular cooling. Quenching followed by tempering is advocated as conferring elastic properties superior to those developed by annealing. F. C. A. H. L.

240. *Manufacturing Wagon and Locomotive Axles.* **L. Geuze.** (Rev. de Mét. 14. pp. 747–757, Nov.–Dec., 1917.)—The steel used is of medium hardness and of strength 45 to 50 kg./mm.^{2}. The ingots are generally of octagonal section and yield 2 to 4 axles, each weighing 400 to 450 kg. If a tailpiece be formed for convenience in forging, it should be as small as possible and its relative importance should be reduced by using ingots yielding 4 axles each. A good section for ingots is square with convex sides and well-rounded corners. Octagonal ingots with concave sides are very liable to yield seams or inclusions of scale, especially if (as in one case mentioned) they be forged to square section before rounding. The furnace atmosphere should be neutral

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or reducing; if it be oxidising, coal may be saved but metal is burnt. In one case the value of metal lost (due to oxidising atmosphere) was more than 17 times the value of the coal saved.

In forging 4-axle ingots, use may be made of a 1500- to 2000-ton press or of a hammer with 20 to 25 tons falling weight. It is desirable that the billet should be as nearly as possible circular. Forging an octagonal billet by working on all the faces two by two amounts simply to drawing out the metal. A square ingot should first be made octagonal by working on the corners. Surfaces are cleaned less easily in a press than when a hammer is used.

The forged blanks are passed through the three stages of a triple die which (*a*) forms the body of the axle to the desired dimension; (*b*) forms the key bosses; (*c*) forges the tail-ends. These three operations demand two heats to produce the rough axle, ready for machining. Octagonal billets well forged may be reheated whilst they are still hot and then need only "1½ heats"; such billets yield 50 axles per 12 hrs., compared with 80 to 85 axles per 12 hrs. working from square billets. The ratio of ingot weight per axle to weight per axle machined is 1·446, 1·37, and 1·34 in the case of ingots yielding 2, 3, and 4 axles respectively. The advantage of the larger ingots is obvious.

A press die with three "ways" is seriously stressed by bending (and often broken) when either of the outer ways is used. A better arrangement is to use dies which can be traversed across the press so that that part of the die which is in use is always in the direct line of pressure. Shafts are annealed in continuous furnaces at max. temperature 850° C., cooled in the furnace to 500° and then cooled in air.

Locomotive axles are made from square ingots, each yielding two axles. A large boss is first forged for the two cranks; this is notched at the centre by a cold saw and one boss is then twisted at right angles to the other. A good margin of material must be left for machining. The ingot weighs about 3·26 times the weight of the crankshaft(s).

Railway specifications now permit ingots to be press-forged instead of hammered. Since rolling has the same effect as press-forging on the structure of the metal, the author suggests that ingots be rolled to circular billets of appropriate diameter. This would simplify manufacture and increase and cheapen production. Equally good results could be obtained and the same guarantees could be given. R. E. N.

241. *Making Tyres for Wheels of Wagons and Locomotives.* **L. Geuze.** (Rev. de Mét. 14. pp. 730–746, Nov.–Dec., 1917.)—The tyres are made from hard steel offering about twice as great a resistance to deformation during manufacture as would be offered by mild steel. The stages of manufacture are forging, piercing, anvilling, and rolling. As regards the ingots, there are two distinct processes: (*a*) Using one ingot for each tyre; (*b*) using large ingots for 6 or 7 tyres each. The latter method is of recent origin, but it necessitates additional costly and bulky plant. An ingot for 6 or 7 tyres may be about 500 mm. diam. and 1·5 m. high, weighing 2110 kg. Allowing for cutting, etc., there is about 21 % scrap, reckoned on the weight of the rough rings for the tyres. The special equipment necessitated by the large ingot system includes a lathe of at least 75 kw. to cut up the ingots and at least one dividing press, with a considerable amount of auxiliary gear in each case. To produce 150 wagon tyres per 12 hrs. requires 4 lathes (60,000 fr. each), 1 press (40,000 fr.), miscellaneous tools (60,000 fr.), site buildings, etc. (100,000 fr.).

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Allowing for labour and capital charges and 21 % scrap, the extra cost is about 4·41 fr. per 100 kg. compared with an ordinary ingot. In the alternative system from 4 to 8 ingots are run at once, each for a single rim. The percentage of scrap is about 15 %, and even allowing for the relatively greater cost of small ingot moulds there is a saving of about 1·18 fr. per 100 kg. in favour of the individual ingot system.

The operations of rough forging, piercing, and forming the blank rim by an anvil machine can be performed in a single heat for wagon tyres up to 800 kg. Locomotive tyres must be reheated after the rough forging and piercing. In both cases the tyre is reheated before being passed through the roughing and finishing "cages" of the rolling mill. Mills with a single cage cannot yield economical production. Using a single motor to drive both cages of a double mill increases the risk of total breakdown. It is best to use a mill with two cages completely separated and each driven by its own motor. The roughing cage is driven at 60 r.p.m. from a 500-h.p. 180-r.p.m. motor. The finishing cage is driven at 65–75 r.p.m. from a direct-coupled 800-h.p. motor. The motors have Ilgner compensator sets and may be varied in speed over a wide range.

The construction and operation of the mill are described in detail; and so are the other stages of manufacture. The dimensions of the individual ingot or of the blank cut from a large ingot are worked out in detail, as well as those of the tyre at later stages in construction. The 1500-ton forging presses generally employed should be much more powerful to give economical production. The presses for the "anvilling" process are of from 800 to 1000 tons, which is adequate. More rapid and regular action could be obtained by using cylinders instead of the anvil and press or hammer combination; the author has patented a machine of this description, but does not describe it here. Hydraulic pressure of 50 kg./cm.^{2} is used during the preliminary rolling; pressures up to 120 kg./cm.^{2} are used during the final rolling, the tyre being then considerably cooler. A needle indicator with a multiplying mechanism of large ratio is used to indicate the diam. of the tyre; its construction and operation are described. The tyres are finally annealed at 800° C., and unless this operation be conducted carefully the tyres will not pass the shock test. R. E. N.

242. *The Heating of Stored Coal.* **C. M. Young.** (Am. Inst. Mining Eng., Bull. No. 184. pp. 211-212, Feb., 1918.)—As a result of large-scale trials carried out at Illinois University it has been observed that the portions of the pile in which fine sizes were present in largest proportion did not contain sufficient oxygen to heat the coal to any noticeable extent. The close packing had also so obstructed circulation that little fresh oxygen could have been brought in, even if the temperature had been raised to such an extent as to favour circulation of air. This indicates that one comparatively safe way to store coal is to use enough of the fine sizes to occupy the space as completely as possible, and to pack the coal tightly in order that the air-space may be reduced and the circulation of air restricted. Apparently the most dangerous conditions exist when the coal is of such sizes as to present a large aggregate surface for absorption, and at the same time to leave a sufficient air space to provide the oxygen required for heating. This condition is found in a loosely-packed pile of "mixed sizes." J. B. C. K.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

243. *Electrolytic Zinc.* **C. A. Hansen.** (Am. Inst. Mining Eng., Bull. No. 135. pp. 615–648, March, 1918.)—In the opinion of the author the failure to obtain good results in the electrolytic deposition of zinc is due to lack of thoroughness in the manner of application, and lack of realising the importance of thorough purification of the electrolyte. No inorganic addition agent has been found which improves the power characteristics of the zinc cell, nor one which improves a commercially pure solution, except to a minor degree. In regard to current efficiency, this should be in accordance with Faraday's constant except for corrosion. To some extent the efficiency falls off as the deposit becomes less smooth, and a large surface is exposed. The corrosion rate is mainly determined by the acid concentration of the electrolyte. A diagram is given showing how this varies. In all probability the corrosion rate is about doubled with each 20 deg. C. rise in temperature. Experiments were made on five or more cells operated in solution cascade, and in electric series. A number of tables and diagrams are given showing the results obtained. Corrosion rates appear to increase with the current density, and higher current densities do yield rougher deposits. There is the further fact that zinc sulphate gains in acid in proportion as it loses in zinc; thus when the zinc becomes sufficiently low, the zinc concentration will have a greater effect upon the current efficiency than the acid concentration. It appears that lack of zinc has at least a fairly important effect upon current efficiency. The main variable, however, is certainly acid concentration. Curves are given showing the voltage required per cell, and the power required, stated as the kw.-hours required to deposit 2000 lbs. of Zn. The impurities that have been encountered in the course of the investigation may be classified as non-cumulative and cumulative. The latter may be grouped into those which have no important bearing upon the deposition, such as alkali metals and Mg, and those which are injurious, such as Ni, Co, and V. Pure solutions invariably yield excellent deposits, but impure solutions lead to pinholes; these arise even with the merest traces of certain impurities. The author is of the opinion that working with any other than pure solutions is out of the question. Finally, some practical expedients are given for the control of zinc cells. W. R. C.

244. *Pig Iron from Scrap Steel.* (Mining and Scientific Press, 115. No. 28. pp. 986–988, Dec., 1917. Am. Soc. Mech. Eng., J. 40. pp. 191–192, Feb., 1918. Abstract.)—Owing to the large quantities of scrap steel which are now being obtained in munitions, this steel is being used for the production of pig iron. The new process is being applied commercially in the United States at the Sweetzer-Bainbridge Metal Alloy Corporation, at Watervliet, N.Y., where two 5-ton Ludlum electric furnaces are used with a daily output of 50 tons per day. Ordinary scrap steel of any grade is introduced into the furnace cold, is melted, and, if necessary, refined. After the desired refinement is reached the slag is removed. The necessary amounts of ferrosilicon and ferromanganese are added to bring the iron to the composition desired, and then the carbon is added in the form of fine coke, which is easily absorbed by

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the hot metal. The regulation of the temperature and composition is quite simple, and a range from high-grade low-phosphorus iron down to the high-phosphorus foundry and other irons is possible. The graphitic carbon content is regulated by the introduction of varying percentages of silicon. A knowledge of the composition of the scrap charged into the furnace permits quite close regulation of the phosphorus and sulphur contents. W. R. C.

245. *High-temperature Resistance Furnaces, with Ductile Molybdenum or Tungsten Resistors.* **W. E. Ruder.** (Am. Inst. Mining Eng., Bull. No. 184. pp. 585–591, Feb., 1918.)—The author describes the use of molybdenum and tungsten resistors for electric furnaces in the laboratories of the General Electric Co. Owing to its greater pliability in heavy sections, molybdenum is commonly used. Its melting-point (about 2550° C.) allows a sufficient range above the softening temperatures of available refractories. This holds true when resistors are run at atmospheric pressures. If, however, it is desired to run at reduced pressures, or in a vacuum, tungsten is used, owing to the higher temperature which is available. Two tubular furnaces are described, one with the tube horizontal, and the other with the tube vertical. Alundum tubes are used for the purpose. Two wires are wound round these, and the space between the tube and the casing is packed with alumina. If the temperature is kept below 1600° C. a long life may be expected; but if higher temperatures are used the alundum tube sags. A vacuum tungsten furnace is also described, due to Coolidge and Hotaling: in this the tungsten tube is used as a resistor, and a temperature of 2000° C. may easily be obtained in 15 mins. In the alundum tube furnaces a temperature of 1700° C. may be obtained in about two hours, but for safety three hours is usually allowed. In these the wire is in an atmosphere of hydrogen. W. R. C.

246. *Booth-Hall Electric Steel Furnace.* (Met. and Chem. Eng. 18. pp. 211–212, Feb. 15, 1918.)—This furnace is made for single-phase, 2-phase, and 3-phase. In the case of a 2-phase furnace, there are two main electrodes, one auxiliary electrode, and two grids buried under the hearth. The method of working is as follows: When the furnace is charged with steel scrap, the auxiliary electrode and the two main electrodes are let down until they rest upon the scrap; the main electrodes are then drawn up, creating an arc under each, the arc being governed by automatic regulators. In this arrangement the auxiliary electrode acts as a common return. When a pool of molten metal is formed on the hearth sufficient to make it conductive, the current begins to flow through the hearth and out through the two sets of steel grids. The fact that this is taking place is indicated by the ammeters, and the auxiliary electrode is then drawn out of contact with the scrap. The furnace continues to operate as a 2-phase furnace, the current from one side of each transformer making a circuit through one electrode, across the arc, through the bath and the hearth to the opposing grid. The advantages claimed are as follows:—The use of an auxiliary electrode makes the starting more positive; the conducting hearth leads to uniform heating; the use of two independent circuits, crossing in the bath, combined with bottom heating, gives a maximum circulation of the bath; the use of an auxiliary electrode enables the use of a minimum number of electrodes for multi-phase work; the hearth is solid, and requires no water-cooling. On an absolutely cold bottom it is necessary to employ the auxiliary electrode for about 45 mins. before the hearth becomes conductive. If the furnace has been shut down over-night this requires from 20 to 30 mins. W. R. C.

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247. *"The Secomor."—A Mechanical Device for predetermining the Characteristics of a Series-wound Polyphase Commutator Motor.* **V. Karapetoff.** (Am. I. E. E., Proc. 37. pp. 65–82, Feb., 1918.)—The "Secomor" (series commutator motor) is a combination of movable and adjustable bars which can be set to represent the vector diagram of voltages, currents, m.m.f.'s and fluxes in a motor of the above type with any desired constants. The theory of the motor is given and it is shown how the linkage system may be constructed to obtain the characteristics under various conditions of loads. Its use enables the designer to select the best electrical constants for a given purpose without having to draw complicated vector diagrams or employ an involved analytical theory. The instrument enables curves to be drawn mechanically for current, torque, speed, input, output, efficiency, power-factor, and magnetising current. The factors that may be varied in setting the apparatus are the ratio between the primary and secondary amp-turns, their ratio to the exciting m.m.f., the angle of brush shift, the ohmic and reactive drops, saturation in the iron, core loss and friction, and the reaction of the short-circuited amp.-turns upon the exciting current. An additional mechanical device permits the impedance drop in the machine to be taken into account. This device includes as one of its component parts a wire bent into the shape of the actual saturation curve of the iron. A. J. M.

248. *D.C. Calibration of Power-factor Meters.* **T. W. Varley.** (El. World, 71. pp. 248–249, Feb. 2, 1918.)—Calibration of a 3-phase power-factor meter by actual adjustment of power-factor requires two voltmeters, one ammeter, one wattmeter, and the services of 5 observers. With variations in voltage and current it is practically impossible to check any point on the scale. These difficulties may be overcome by using direct current and adjusting the resistance in the moving coil circuits to give relations shown in a table presented by the author. This table is based upon the fact that the deflection of a dynamometer type power-factor meter is equivalent to the combined torques of the moving coils in the field of the load coil. By adjusting the ratio of the currents in the moving coils the resultant torque with direct current can be made equal to any obtained when the instrument is connected to a polyphase circuit of any power-factor. The current in one of the circuits will have to be reversed, in addition to changing the resistance ratio, in order to obtain deflections corresponding to power-factors of 70° or less (2 phase), and 40° or less (3-phase). When calibrating a single-phase power-factor meter, a resistance may be used in the d.c. set-up, to simulate the condenser effect. Numerical examples for a number of cases are given in the original. The resistance ratio method of calibrating power-factor meters necessitates only one man to mark the scale, and no attention need be paid to variations in voltage or current. R. E. N.

249. *Experimental Study of the Fahy Permeameter.* **C. W. Burrows** and **R. L. Sanford.** (Bureau of Standards, Bull. 14. pp. 267–300 [Sci. Papers, No. 306], 1917.)—This apparatus is H-shaped with test coils ST spanning the free ends of the H and a magnetising coil M wound on the cross-piece. D and D′ are also test coils. SDD′T have the same number of turns and are connected in series and in such a manner that the integrated e.m.f.'s induced in S and D′ when a magnetising current is reversed in M are in the same direction but in opposition to those simultaneously induced in D and T. The permeameter is initially adjusted so that when the coils S and T encircle air the differential effect of the coils D and D′ is zero. In use, S

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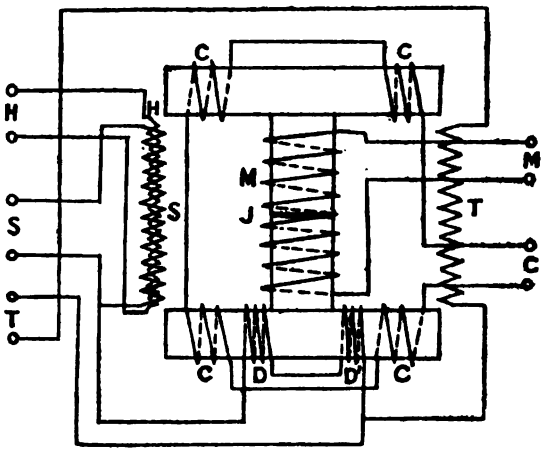
encircles a standard bar bridging the gap on the left and T the test-bar bridging the gap on the right. In the cross-bar is an air-gap J, designed to create a demagnetising force within the core itself and which is adjustable to suit requirements. Magnetomotive force can also be applied in the compensating coils C and the currents in M and C are independently adjustable. When current is flowing in both M and C one magnetic circuit has its m.m.f. increased and that of the other circuit is diminished by an equal amount. Thus by varying the current in the compensating coils the difference in fluxes linking the test coils D' and T can be made equal to the difference in fluxes linking S and D. When these flux differences are equal, the leakage flux through the air path which is in parallel with the path of the coil T is equal to the leakage through the air path in parallel with S. Since these two paths are symmetrical and carry the same flux, the same difference of mag-



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netic potential exists between their ends. Coil H has a relatively large number of turns. It is wound on the same form as S and may be used to measure the difference of magnetic potential in this region, and hence the mean magnetising force, which will be that obtaining along the path of T in which the test specimen lies. The authors have made a critical study of this permeameter, the chief points dealt with being consistency of repetition, effect of length of test specimen, reluctance of joints, effect of iron in the vicinity, position of specimen on the pole-faces, and strain effect. They are led to the conclusion that the instrument represents a distinct advance on direct-reading permeameters in common use. Normal induction measurements of solid bars show errors no greater than 5 % of the magnetising force required for a given induction. Commercial materials are seldom uniform enough to warrant better precision than 5 %. Preliminary experiments indicate the possibility of its adaptability to the measurement of sheet materials. An appendix to the paper gives a very complete description of the instrument and the method of procedure for obtaining normal induction measurements, either absolute or comparative, and hysteresis curves. L. L.

250. *Measurement of Power by Kathode-ray Oscillograph.* (U.S. Pat. 1,219,961. El. World, 70. p. 760, Oct. 20, 1917. Abstract.)—According to I. Langmuir he has been able to devise an arrangement by which not only

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are the irregularities of the original vacuum tube overcome but an exceedingly effective screen is proposed which does away with all difficulties inherent in the usual fluorescent screen.

Contrary to the idea of employing a small amount of ionisable gas in the Braun tube to conduct the electrical discharge current, the Coolidge idea is embodied. In this an incandescent kathode is employed emitting negative electrons in an "atmosphere" as low as $0{\cdot}01\mu$. This high degree of exhaustion is effected by means of the Gaede molecular pump.

A perforated plate is arranged to close one end of the tube to serve as the main anode for the source of energy. The greater part of the electrons given off by the kathode will strike the plate, and those travelling in a direction parallel to the axis of the envelope will pass through the aperture in the plate, through the tube, and through a second aperture, closing the other end of the tube. In this way a pencil of rays is produced which is directed upon a reflecting screen.

In the path of the kathode ray, before it reaches the deflecting screen, are arranged two sets of electrostatic deviators which cause the travelling negative electrons to take up two types of lateral deflection compounded at right angles to each other and directly proportional to the voltages and current effects it is desired to outline. In this manner, after reflection, with the rays impinging on a screen having a finely divided deposit of volatilised tungsten or molybdenum, the surface of the screen traces out an incandescent path, showing how the kathode-ray pencil is deviated from its normal central stationary position. The area of the diagram or the area enclosed by the path of the kathode rays on the screen may be measured, and after the instrument has been suitably calibrated the power in the circuit may be computed from this area. L. H. W.

251. *Characteristics of Thermal-storage Demand Meter.* **P. M. Lincoln.** (Am. I. E. E., Proc. 87. pp. 147–168, Feb., 1918.)—Practically all other types of demand wattmeters register the arithmetical average demand during a certain time interval, whereas the "thermal-storage" demand meter registers the "logarithmic average" demand [Abs. 1123 (1915)]. The pointer-spindle of the instrument is fitted with two bimetallic spiral springs wound in opposite directions so as to compensate for change in atmospheric temperature. Each spring is contained in a "thermal-storage" case and is heated by a resistance. The circuits of the instrument are so arranged that the current through one resistance is $(E + I)$ and through the other is $(E - I)$, where I represents the load current and E is a current proportional to the voltage across the mains. The deflection of the pointer is due to the *difference* between the heating of the two spiral springs, *i.e.* to $(E + I)^2 - (E - I)^2$. The deflection is thus proportional to EI. This holds good, independently of power factor and wave-form. The deflection at any moment is not due to the watts passing at that instant (as in an ordinary indicating wattmeter), but is the resultant of all wattage flow that has passed, each instant of past flow having an influence which decreases with its remoteness in point of time, according to a logarithmic law.

Practically all demand indicators hitherto employed have indicated an *arithmetical* average; generally a standard watt-hour meter has been coupled with a timing device so as to integrate the load over successive short intervals of time and record automatically the highest integrated total attained. Such a "block-interval" meter does not discriminate between a severe isolated load and one which corresponds to the same energy flow but is distributed

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throughout the time period of the meter. Also the meter period may halve the period of an isolated block of load, in which case the meter record is only half what it should be. If the load is steady over long periods, the block-interval and thermal-storage meters give exactly the same result, but where short-period loads are concerned, the thermal-storage meter gives a far more accurate measure of the true heating effect in the supply generators, etc.; also, the thermal-storage meter is perfectly definite in its indication irrespective of the moment of incidence of short-period loads. On very short load applications, the indication of a thermal-storage meter is about 168 % of the maximum and 826 % of the minimum indication of a block interval meter.

The author shows how to calculate the logarithmic average of a given load from purely theoretical considerations. Also, he explains why the meter does not indicate a true logarithmic average for isolated short-time loads. Such error as is introduced is small in practice and is in favour of the consumer (by underestimating his demand when the latter is in short-period isolated blocks).

With an increasing load the maximum is applied when the meter element is hottest, whereas with a decreasing load the full block of load is not completed until the meter element is coolest. Hence the reading of a thermal-storage meter is less on decreasing than on increasing load, other factors being the same; and the max. indication is obtained before the entire block of load has passed. This action is quite defensible, because the heating effect of decreasing load on generators, cables, etc., is less than that of increasing load for exactly the same reason, the kw.-hrs. and time of application being the same in each case. When the thermal-storage meter is employed it is no longer necessary to use very short meter periods to penalise consumers with high time-peak loads. R. E. N.

252. *The Force of Repulsion in Disconnecting Switches.* **H. B. Dwight.** (El. Rev., Chicago, 71. pp. 684–686, Oct. 20, 1917.)—The author derives formulæ for the average force, or the steady push, exerted by the current and tending to force open disconnecting switches. Curves are also included showing values of the repulsion for various values of the ratio A/B and also of the ratio B/S, where A is distance between one conductor and the blade, B that between the two posts connected by the blade when in the "closed" position, and S the distance between the blade and the return conductor. If the circuit does not return behind the switch the term B/S becomes zero. When A < B the average force, F, in lbs. is given by the simplified formula: $F = [I^2/(4{\cdot}45 \times 10^7)][2{\cdot}30 \log_{10}(B/D) + 0{\cdot}69B/A + B^2/4A^2 + B/S]$.

A practical example is worked out. L. H. W.

253. *Report of the Joint Rubber Insulation Committee,* 1916. (Am. I. E. E., Proc. 86. pp. 871–890, 1917.)—Part I. forms the general Report; II. gives the specification for 80 % Hevea rubber compound; III. deals with the analytical procedure; IV. furnishes an explanation of the specification adopted, while Part V. gives an explanation of the procedure. L. H. W.

254. *Testing Instrument for Electric Ignition Apparatus.* **J. D. Morgan.** (Engineering, 105. pp. 187–188, Feb. 8, and p. 212, Feb. 22, 1918.)—The author passes the current from the magneto to be tested through a metal filament of high resistance, *e.g.* from 500 to 1500 ohms, arranged in a glass vessel, the interior of which is connected to one limb of a capillary U-tube containing a liquid indicator. The other limb of the U-tube is

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connected to a similar vessel, the filament of which is connected in an electric circuit including a battery, a variable resistance and a milliammeter. The resistance is then adjusted so that the heating effects in the two vessels balance one another. The milliampere readings may be taken as the equivalent of the magneto current when balance is obtained. The author has found that if the heated element is of low resistance, the instrument readings will be determined mainly if not solely by the high-frequency component of the magneto-current, whilst if it is of high resistance the readings will be determined mainly if not solely by the low-frequency component. He is of opinion that the current of lower frequency is the more useful for comparative measurements, so that the heater filaments should be of relatively high resistance as mentioned above. C. A.

255. *Current Intensities in High-voltage Cables.* **E. Soleri.** (Elettrotecnica, 5. pp. 54–58, Feb. 15, and pp. 75–77, Feb. 25, 1918.)—The Electrical Associations of different countries are not in agreement as to the intensities of currents which may be allowed to flow through a cable for high or very high voltage. The rules which were given are either empirical or do not take into account all the elements of the problem. In particular, the increase in temperature due to the losses in the dielectric is not considered in the said rules. The purpose of this article is that of setting forth the methods for determining the current intensity for high-pressure cables, taking into account the losses in the insulating substance. These, for some substances such as mica, paraffin, etc., are proportional to the square of the dielectric stress, but for other substances, such as india-rubber, impregnated paper, etc., the losses are proportional to a higher power of the dielectric stress: in other words, for substances of the first class $\cos\phi$ is independent of the pressure, whilst for substances of the second class it increases with the pressure. This fact was already known and is confirmed by the author's experiments. The temperature has a bad influence both upon the resistivity and upon the losses in the insulating substance; but, whilst the diminution of the resistivity is negligible from the point of view of increase of losses, the augmentation of the dielectric hysteresis can be so important that the losses due to them could, according to certain experimenters, become of the same order as the ohmic losses. The author has experimented on some cables insulated with different substances, and has found that although the dielectric losses effectively increase with the temperature, they are far from reaching at full load those for Joulean heat. In any case it is necessary to take into account the dielectric losses in order to establish the max. admissible current for cables. These losses depend upon many factors, such as the electric resistivity to alternating current of the dielectric, its thermal resistivity, electrostatic capacity, etc. The author shows several forms under which the admissible current in cables can be expressed. One of these forms is the following: $I = [(W - W_d)/R]^{1/2}$, where W represents the losses for Joulean heat, W_d those in the dielectric, and R the ohmic resistance of the conductor.

The dielectric stress through the insulator can generally be considered as uniformly distributed throughout its thickness. In this case important simplifications can be obtained and diagrams can be drawn for the calculation of I.

As to the max. temperature to be allowed in cables, the author concludes that the generally adopted max. temperatures can be used also when the losses for dielectric hysteresis are taken into account. E. B.

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256. *Measurement of Power Loss in Dielectrics of Three-conductor High-tension Cables.* **F. M. Farmer.** (Am. I. E. E., Proc. 37. pp. 125–145, Feb., 1918.)—It is usual to determine the power loss in the dielectric of 3-conductor cables by making single-phase measurements and computing the 3-phase loss. But assumptions have to be made in the calculations which may not be entirely justifiable. The author has therefore measured the power loss directly under 3-phase conditions. A full description is given of the method employed, and the results are shown in a series of graphs. The measured value seems frequently to be lower than the calculated value, which does not substantiate the theory put forward that the power loss would be greater in the dielectric between the conductors with 3-phase potential; but this point should be further investigated. The results show that for all practical purposes, calculations based on single-phase measurements may be considered sufficiently accurate. V. C.

257. *Electrical Properties of Vulcanised Fibre.* **W. Eves.** (El. World, 71. pp. 190–192, Jan. 26, 1918. El. Rly. J. 51. pp. 238–239, Feb. 2, 1918.)—The author deals chiefly with the electric strength of various kinds of fibre—grey, black, and red. The breakdown volts per mil depend on the thickness of the vulcanised fibre, the extent of the gelatinisation of the plies of paper, the temperature of the sample at time of test, and the colour to some degree. The conditions of the material likely to affect the volts per mil are the amount of chemical remaining in the fibre, the moisture density, and the physical shape of the sample. The author deals briefly with these conditions and gives curves showing the variations of the breakdown voltage with temperature of fibre of different thicknesses and colour. Generally the red fibre has a lower electric strength than the grey. Black fibre is usually between and nearer the grey.

Of other properties, vulcanised fibre has the following strengths in lbs. per sq. in.: Tensile, 9000-13,000; compression, 38,000–48,000; shearing, 9000–13,000. It loses its pliability by application of sustained temperature 80°–100° C. and at 200° C. commences to char. Most dilute acids and alkalies cause no other effect than the effect of water. Organic solvents and oil have no effect.

The general uses for insulation are touched upon; one of the largest uses is for railway signal insulation. The Railway Signal Association's specifications require a specific gravity of 1·3 to 1·5, an absorption (when immersed in water at 70° F. for 24 hours) not to exceed 45 % by weight for $\frac{1}{8}$-in. fibre, 30 % for $\frac{3}{16}$-in., and 26 % for $\frac{1}{4}$-in.; a tensile strength of 5000 lbs. per sq. in., and electric strength of 82 volts per mil for all thicknesses under the application of voltage for 1 minute between disc electrodes 1 in. in diameter. J. L. L.

258. *Developments in the Electrical Industry during* 1917. **J. Liston.** (Gen. El. Rev. 21. pp. 4–52, Jan., 1918.)—A complete record of electrical developments during 1917 may not be published under present conditions. There was enormous increase in production of standard apparatus for power station, railway and industrial equipment. The increase amounted in many cases to several hundred per cent. on previous maxima, and very rapid production was accomplished in many instances. The author gives leading particulars and examples of work done in the following fields: Turbines, a.c. machines, automatic hydro-electric stations; d.c. motors; electric traction; mining and industrial locomotives; mine hoists; loading equipment for piers; cranes; furnaces; steel mills; sugar, paper, and rubber mill equipment;

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research work; rectifiers; static condensers; transformers; standardisation; arresters; switchgear; heating equipment; and lighting.

A special spring-supported thrust bearing has been standardised on GE. vertical-shaft generators. Spiral carrier springs permit the bearing to adjust itself automatically in the event of loss of alignment by foundations settling or other causes. Four 6250-kv.a. gas-driven alternators carry the rating for gas-engine generating sets beyond any earlier maximum. A 8 × 500-kw. hydroelectric equipment at Cedar Rapids, Iowa, operating in parallel with a steam plant ½ mile away, represents the first commercial application of automatic control to service of this nature. A new line of adjustable-speed motors ranging from 2 to 125 h.p. embodies a distributed compensating winding embedded in slots in the main pole-pieces, in addition to the commutating-pole winding. These motors may be accelerated from low to high speed when connected to a friction load, by inserting the total field resistance in one step.

Schemes for the electrification of heavy traffic and mountain grade railways have been shelved until after the war, but lines already electrified have ordered extra equipment and accomplished much development work. Particulars are given concerning individual lines. About 45 automatic sub-station equipments are in use or under construction at Schenectady. A number of recent mining and industrial locomotive equipments and a number of mine hoists, etc., are described. A new single-reduction battery locomotive is an important development. There was a great demand for small crane motors, principally for use in shipyards, and the production of d.c. crane motors was more than double that of any preceding year.

A number of 20-ton electric furnaces were put in operation in 1917 and an early advance to a standard maximum of 80 tons is anticipated. The rate of steel production has been increased by the use of higher capacity transformers and high voltages. Using higher voltage during melting, the current is decreased, the power factor increased and higher emergency input secured when desired. There was a remarkable increase in the kw. capacity of auxiliary drives, control, transformers, motor-generators, and other electrical equipment of steel rolls. A new electric driving system was devised for sugar-cane crushing mills; a load regulator was introduced for paper pulp grinders; and a new semi-automatic control was devised for motors driving rubber calenders.

Kenotron rectifiers have been applied in a number of cases to precipitating smoke and fumes, etc.; and 5000 "Tungar" rectifiers are used in a great variety of applications, principally for charging secondary cells. The chief developments in the transformer field are the introduction of an automatic voltage stabiliser; the building of a 25,000–50,000-kv.a. auto-transformer, 12,200/24,400 volts; and the development of a new tank comprising a corrugated tank with external radiators. Circular coil transformers are well adapted to electric furnace conditions. The oil conservator tank has been further developed.

Tables are given showing standard types, frequencies, voltages, tappings, and ratings for transformers to be used in generating stations; substations; distribution schemes; and synchronous converter and motor-generator installations for industrial and mining installations, etc. Progress in switchgear is reviewed and illustrated. Developments in the heating field include a circulation water heater with thermostatic control; electric bake ovens; heavy ranges and submarine ovens. The Mazda C lamp for kinematograph

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projectors; the sale of 75 million miniature tungsten lamps; improved photometric equipment; and improved diffusing and other fittings represent the principal developments in the lighting field. R. E. N.

259. *A Constant-torque Electromagnetic Clutch.* (Electrician, 80. pp. 613–614, Jan. 25, 1918. Engineer, 125. pp. 78–80, Jan. 25, 1918.)—This clutch, due to W. Langdon Davies and A. Soames, has three windings. The windings, A and C, have many turns of fine wire, while B is a series coil with a few turns of thick wire. A is energised from the mains or from a small exciter on the driving shaft. B is in series with the dynamo armature, and its polarity is such that it tends to counteract the pressure produced by A. As the load increases, the current in B also increases, till the pressure between the clutch surfaces just suffices to transmit the load. The current first rises and then falls owing to the slip of the clutch, which lowers the coefficient of friction. To counteract this C is introduced and is connected across the brushes of the dynamo, its polarity also opposing that of A. When the slip begins the volts across the dynamo decrease, thus diminishing the effect of C or increasing indirectly the effect of A. In this way the pressure is adjusted so that the current remains practically constant. Drawings are given showing the details of the design. W. H. S.

260. *Increasing Current Capacity of Underground Cable.* **E. O. Schweitzer.** (El. World, 71. pp. 613–614, March 23, 1918.)—With the object of cooling the cable, the author proposes to replace the air in a duct by vaseline; crude vaseline has a very high viscosity, and does not liquefy at any safe operating temperature, so that it will not tend to escape from the duct; it affords mechanical support for the cable and prevents abrasion of the lead sheath. Owing to its heat dissipating properties, the cable will be considerably cooled (in a given case by 14 %); the degree of effectiveness of the vaseline apparently increases at high temperatures. The temperature distribution along the cable will also tend to be more even, and "hot spots" consequently eliminated. Water has also been suggested for this purpose but there is great danger from electrolysis and corrosion of the lead sheaths; if vaseline is used, it is believed that trouble due to electrolysis will be eliminated; tests are being carried out to prove this point. In a case quoted, to obtain 7 % increase of carrying capacity would cost $7770, whereas obtaining it by using vaseline filler would cost only about 4000; an approximate net saving of $3770. V. C.

261. *Rating and Selection of Oil Circuit-breakers.* **E. M. Hewlett, J. M. Mahoney** and **G. A. Burnham.** (Am. I. E. E., Proc. 37. pp. 41–56, Feb., 1918)—The authors discuss the interpretations of the Am. I. E. E. Rules covering the rating of oil circuit-breakers, and the factors involved in the proper selection of suitable apparatus. They also suggest a plan by which it might be possible to calculate the short-circuit characteristics for a network of normal type, and in this way they think there might be less difficulty in making a selection. The determination of the short-circuit current is evidently of importance, and curves are given showing the time-current curves with different total reactances on short-circuit, assuming the machine to be delivering full load with a power factor of 0·8. The authors consider that in these curves the r.m.s. value of the total current wave should be taken instead of the peak value, and also the effect of the increased flux existing under the assumed load condition should be considered. These considerations have the effect of reducing the ratio between the short-circuit and rated amperes, and

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secondarily of increasing the short-circuit current by a somewhat less percentage than the alternator reactance percentage. The curves are said to be applicable for selecting circuit-breakers for (1) single machines without external reactance, (2) single machines in combination with external reactance, (3) multiple machines with no external reactances, and (4) multiple machines in combination with external reactance. Several examples are given showing how the curves can be used to determine the short-circuit current. In one of these, which is quoted by way of an example of the simplest kind, the alternator gives 1250 volts 3-phase, and 1250 amps. The contacts open in 0·25 sec. From the table under 12 % reactance, we find that at 0·25 sec. the current will be 5·54 times the normal, *i.e.* 6950 amps. Other cases take into account the reactances of transmission lines, transformers, alternators, etc. Different conditions arise when automatic voltage regulators are used, and some final notes are added dealing with some of the more usual abnormalities. Manufacturers are urged to publish particulars of their apparatus on the lines suggested in this paper. W. H. S.

262. *Automatic Extinction of Fires in Transformers, Oil-switches, etc.* **K. Heinrich.** (Elekt. Zeits. 38. pp. 534–535, Nov. 8, 1917.)—The firm of Wintrich and Goetz, Bensheim, has designed a new automatic apparatus for extinguishing fire, that is particularly adapted for use with transformers, oil-switches, etc. The apparatus is in many respects similar in appearance and design to the "Minimax" fire extinguisher, from which it differs in the method of producing the pressure to eject the fluid from the interior and in the nature of the fluid used. Instead of producing the gas pressure by a chemical reaction, a small container holding compressed nitrogen is screwed into the top of the apparatus. This gas is released by striking a knob, which in turn hits a sharp pin that punctures a disc that closes the gas container. The fire-extinguishing liquid seems to be a volatile incombustible carbon compound, which by its volatisation withdraws heat so rapidly from the conflagration that further combustion is impossible. The liquid is perfectly non-conducting to electric currents, as has been shown by tests at 40,000 volts in which the jet was projected against an arcing horn-discharger.

In order to render the apparatus automatic in its action it is set up so as to feed a pipe line running through the various transformer and switch chambers to be protected. In each chamber two outlets from the pipe are provided, one near the ceiling over the apparatus and one near the floor. Both these openings are closed by fusible plugs. Connected to the upper opening by a fusible wire is a weight. If the temperature at the top of the chamber rises owing to a conflagration, the fusible plug and the fusible wire melt; the first opens the passage for the extinguishing fluid and the second releases the weight. This releases a cam holding a weight suspended above the fire extinguisher. This weight falls on to the knob that punctures the gas container and the fluid is forced through the pipe line and is poured over the centre of the fire. If burning oil overflows on to the floor in any of the chambers, the lower fusible plug opens and the liquid issues from this outlet as well as from the one in the ceiling. A. J. M.

263. *Electrical Cooking as applied to Large Kitchens.* **W. A. Gillott.** (Inst. El. Eng., J. 56. pp. 92–102; Disc., 102–112, Jan., 1918. Abstracts in Electrician, 80. pp. 836–837, Dec. 7, 1917. El. Rev. 81. pp. 597–598; Disc., 598–600, Dec. 21, and pp. 621–623; Disc., 623–624, Dec. 28, 1917. El. Rev., Chicago, 71. pp. 1095–1099, Dec. 29, 1917.)—This paper gives particulars

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of the results obtained at four large installations, namely, A, a restaurant where the menu is of a very varied nature; and B, C, D, canteens for feeding the staff of large firms, at B and C the menu being only slightly varied to suit the different classes of persons catered for. From the experience gained the author makes the following recommendations:—Two pairs of cables should be brought from the main distributing centre to each servery and kitchen. Where a connection is required from, say, a hot-plate to the terminal chamber, the wiring should be run in solid-drawn tubes instead of flexible metallic tubing. All elements except the grills should be connected in series parallel and so arranged that, after the cooking has thoroughly commenced, they can be switched to "low" and provide sufficient heat to complete the operation. Where the heating elements are clamped under pressure, the pressure plates should be of strengthened cast iron instead of wrought iron, also cast iron or steel should be used in place of copper for the bottoms of large boiling units. Where large quantities of water are required for tea-making, the water should be preheated to a temperature of approximately 160° F. by means of a coke boiler or steam, the final boiling being carried out in self-contained electric urns. If it is kept preheated at temperatures above 160° F., it becomes "flat" and good brews of tea cannot be obtained from it. The main results of working are as follows:—

Installation.	Period of Observation.	Consumption in Units.	Average Number of Meals per Week.				Cost of Maintenance per 1000 Units Connected.	Kw. Connected.
			Breakfasts.	Lunches.	Teas.	Total.		
A ...	10 months	122,052	889	5186	3943	9518	1s. 6½d.	247·6
B ...	1 year	97,140	204	1480	1260	2944	2s. 9d.	180·9
C ...	1 year	21,141	211	452	328	991	8s. 9½d.	40·5
D ...	1 year	20,690	48	371	221	640	4s. 6½d.	82·8

In installation A there is in addition to the above a weekly average of 600 Bovrils and hot drinks. The consumption of energy per person per meal is 0·29 unit. *In installation B* the consumption per person per meal is 0·5 unit. *In installation C* the consumption per person per meal is 0·41 unit. *In installation D* there are in addition to what is given above a weekly average of 106 Bovrils and hot milks, 50 lbs. of bread baked, and 9 suppers. The consumption per person per meal is 0·51 unit. This installation has been catering for 100 % more people than originally intended. In installation A there were 17 wiring faults and 4 earthing and terminal faults; in B, 27 wiring and 25 earthing and terminal faults; in C, 14 wiring and 3 earthing and terminal faults; and in D, 17 wiring and 2 earthing and terminal faults. The costs of the electrical apparatus as compared with equivalent gas and mixed coal, gas and steam apparatus are as follows:—

Installation.	Electricity.	Gas.	Mixed Coal, Gas, and Steam.
	£ s. d.	£ s. d.	£ s. d.
A.....	1446 19 0	1169 0 0	1275 0 0
B.....	566 6 0	488 0 0	536 0 0
C.....	108 12 0	98 10 0	—
D.....	111 12 6	104 8 0	—

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In the *discussion*, **A. F. Berry** stated that the consumption per person per meal in his experience is only about ¼ unit. **C. G. Nobbs** gave a careful analysis of the running and maintenance costs, tending to reduce the disparity between the costs of the several installations. **H. Brazil** suggested the use of fireclay supports for the heating elements instead of mica. The **Author**, in reply, stated that two men are sufficient to keep in repair 200 installations, of which a large number include electrical kitchens. He confirmed the results heretofore published that the shrinkage of meat roasted in electric ovens is only from 10 to 17½ %, as compared with 22 to 35 % with gas and 30 to 40 % with coal, and suggested that the gaps in station loads between 6 p.m. and 8 a.m. should be filled by the use of electricity in bakeries. He advocated reducing the number of hot-plates of the enclosed type, as the majority of faults are met with there. C. A.

264. *Electric Welding.* **J. Guerner.** (Rev. Gén. d'Él. 3. pp. 173–181, Feb. 2, 1918.)—In this article the author gives a brief description of all the modern systems of electric welding in commercial use, and their various applications. Soldering, brazing, and oxy-acetylene welding are also mentioned, as well as a new process of using an electric arc in combination with a gas flame, whereby exceedingly high temperatures are attained, particularly for cutting metals. Welds made by the arc process are harder and more brittle than the original metal, which seems to be carburised at the point of junction, while those made by the resistance method possess appreciably the same mechanical properties as the original metal, with a slight diminution of elasticity. The following results were obtained from tests on electric resistance welds :—

	Tensile Stress, kg./mm.².	Elongation at weld, %.
Iron plates, unwelded	31,850	28·75
„ „ welded	31,200	18·30
Mild steel rods, unwelded ...	44,500	27·10
„ „ welded	44,100	17·60
Sheets, unwelded	41,750	11·00
„ welded	43,600	18·00

For welding on a small scale only the older methods are applicable. For large pieces and for important repairs the autogenous weld is recommended, as the apparatus is simple and portable. For repetition work electric welding possesses the advantages of usefulness, reliability, and economy. In the manufacture of trench bombs the use of electric arc welding resulted in a saving of from 15–20 %, as compared with oxy-acetylene welding.

R. J. W.-J.

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GENERATORS, MOTORS, AND TRANSFORMERS.

265. *Stresses in the Core-punchings of High-speed Rotors.* **W. Knight.** (El. World, 71. pp. 91–92, Jan. 12, 1918.)—Formulæ are developed for calculating the stresses in the core-punchings of high-speed rotors. If W is the weight of the length of the winding embedded in the slots, R′ the radius of the centre of gravity of this weight, n and t the number and thickness of the core-punchings, R the radius at the bottom of the slots, N the speed in revs. per min., then the centrifugal force of the projecting masses per sq. in. of outer surface is $F = 0{\cdot}000841WR'N^2/2\pi Rnt$. Also the tangential stress of a thin steel ring is $T = 8R^2N^2 10^{-6}$. The radial and tangential stresses σ_r' and σ_t' for the punchings only are given by $\sigma_r' = T\{0{\cdot}408[1 + m_0^2 - m^2 - m_0^2/m^2]\}$ and $\sigma_t' = T\{0{\cdot}048[1 + m_0^2 + (m_0^2/m^2)] - 0{\cdot}284m^2\}$ and the radial and tangential stresses σ_r'' and σ_t'' for the projecting portions only are given by $\sigma_r'' = F[1 - (m_0^2/m^2)]/(1 - m_0^2)$ and $\sigma_t'' = F(m^2 + m_0^2)/[m^2(1 - m_0^2)]$, where $m = x/R$ and $m_0 = r/R$ and x is the radius at any point and r the radius at the bore of the disc. The stresses at the bore and periphery are obtained by putting $m = m_0$ and $m = 1$ respectively in the above equations. The simplified formulæ for these cases are given. Curves are plotted by which the arithmetical evaluation of the quantities from the equations is shortened.

A. J. M.

266. *Method of Calculating the E.M.F. of an Alternator.* **H. Pécheux.** (Rev. Gén. d'Él. 8. pp. 204–207, Feb. 9, 1918.)—If the e.m.f. of an alternator does not follow the sine law, the usual methods of calculating its effective value from the dimensions of the machine are somewhat complicated. A simple method of carrying out this calculation is given for a ring armature. If the e.m.f. in one coil of a given breadth is zero for a time $2a$, increases uniformly for a time b to its max. value E_0, which it maintains for a time $2c$, and then decreases uniformly to zero in a time b, it is shown that the effective value E_e of the e.m.f. is given by $E_e = 2E_0\sqrt{[(b + 8c)/8T]}$, where T is the time of a complete period. Furthermore the average value E_a of the e.m.f. is given by $E_a = 2E_0(b + 2c)/T$. Combining these results we obtain $E_e = E_a \times [T/(b + 2c)] \times \sqrt{[(b + 8c)/8T]}$. In this expression $E_a = 4nNP$, where n is the speed of the machine in revs. per sec., N the useful flux cutting each turn, and 2P the number of conductors on the armature. The same method, with slight modifications, is applicable to drum armatures and to armatures with slot windings.

A. J. M.

267. *Turbo-rotor Cap-rings.* **R. Roberts.** (Electrician, 80. pp. 576–578, Jan. 18, and pp. 607–609, Jan. 25, 1918.)—The usual method of supporting the ends of the rotor coils of turbo-generators is by means of cap-rings of steel or manganese bronze. If the windings are concentric the centrifugal forces are not evenly distributed around the periphery of the ring, and some manufacturers add weights to equalise the distribution of the load. This method is objectionable. The coils may be wound so that the radii of the corners of the coils are the same for all coils of a group, or the inside coil may be wound with as small a radius as possible and with the radii of the outer coils as large as permissible. The former is the more common, and requires less jigs and tools, but more copper. Both types of windings are considered, the stresses being separated in each case into (i) self hoop stress, (ii) load hoop stress,

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(iii) support shear stress, (iv), end-ring stress, (v) constructional stress, (vi) summation of stresses, and (vii) link stress : (i) is due to the mass of the ring itself, (ii) is due to the winding, (iii) is the shearing stress at a point caused by a difference between the resultant of the tangential forces on either side of the point and the radial force at that point, (iv) is the stress caused by moments tending to turn the ring inside out, (v) is an allowance for shrinking the caps on to their supports and for expansions due to temperature changes, (vi) is obtained by adding the stresses in their correct directions, and (vii) is the stress caused by the unusual construction in which the outer end of the ring is left unsupported. After calculating the various stresses and tabulating them for different positions, it is concluded that the end winding should be designed as far as possible so as to give uniform load distribution, this being easiest to attain if the radii of the ends of the coils are all small and equal, the centre of gravity of the end winding should coincide in an axial direction with that of the cap-ring, the thickness of the supporting lips should be such as to carry the support shear forces without risk, the cap ring should be solid and capable of withstanding high stresses particularly in the circumferential direction. The max. permissible speed and the amount of metal used in the cap-ring depends greatly on the specific weight of the material employed.

A. J. M.

268. *Note on the Theory of Blondel concerning the Armature Reaction of Alternators.* **A. Léauté.** (Comptes Rendus, 168. pp. 1106–1108, Dec. 31, 1917.)—If an alternator is supposed to be operated at constant excitation and with variable current output, but giving a constant terminal voltage the extremity of the vector representing the (Joubert) internal e.m.f. lies on a Pascal limacon. A simple construction of this curve is given. It is shown that the power output of the machine decreases as the phase lag increases, the law being given in terms of three parameters. A. J. M.

269. *Calculation of the Transverse Field in the Slots of Unloaded Armatures.* **L. Dreyfus.** (Archiv f. Elektrot. 6. pp. 165–224, 1917.)—A theory is developed concerning the production of the transverse field in the slots of electric machines. It is important to be able to calculate this field if a machine is to be designed to give its greatest output, as the pulsation of the transverse field causes losses in the conductors that may equal or even exceed the normal resistance losses. A number of authors [Abs. 865 (1916)] have referred to the character of the transverse field and have published experimental results, but a complete theory is still missing. It is first shown that the magnitude of the transverse field increases from zero under the pole-centres to a maximum near the pole-tips and decreases again to zero midway between the poles. This distribution round the armature at a given slot-depth is worked out. The distribution of the transverse field along the depth of the slots is then calculated. The results of these investigations are expressed by rather complex differential equations. These are applied to numerical cases for straight slots and for radial slots. The calculations involved are lengthy and somewhat complicated, but the author claims that the results arrived at are such as to permit simple and rapid calculations to be made in special cases. A. J. M.

270. *Commutation in A.C. Machinery.* **M. C. A. Latour.** (Am. I. E. E., Proc. 37. pp. 169–194, Feb., 1918.)—In previous publications and patent specifications the author has contended that if L_ω is the inductance per phase of a polyphase winding when stationary, the inductance becomes

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$L(\omega - \omega_1)$ when the armature turns with an angular velocity ω_1 in the direction of the field. Consequently the value becomes zero at synchronism, and the winding acts as a capacitance above synchronism. This view has been questioned by many writers, and particularly by Leblanc. This controversy is now renewed, and the statement is found to be true when the distribution of the flux on the surface of the armature is sinusoidal. If the distribution of flux is considered on the surface containing the axes of the conductors in the slots, then the inductance is $L(\omega - \omega_1 X)$, where $X = 1$ for a sinusoidal distribution, and $X = 8/\pi$ for a triangular distribution of the flux, the winding being for two-phase current. Expressions of this type are evaluated for windings with different numbers of phases. Discussing commutation, it is concluded that this is assisted by the production of a perfect revolving field in a polyphase commutator motor. In the case of the single-phase commutator motor the revolving field can be produced at synchronism by placing auxiliary short-circuited brushes at right angles to the main brushes. The formation of a perfect rotating field is improved by using fractional-pitch windings on the rotor and a sinusoidal distribution of the conductors on the stator. A. J. M.

271. *Note on the Theory of the Magneto.* **J. Bethenod.** (Rev. Gén. d'Él. 3. pp. 276–277, Feb. 23, 1918.)—In a previous article [Abs. 792 (1915)] H. Armagnat gives the formula $i = nS(B - B_f)/L$ for the current in the armature of a magneto. The symbols have the following meanings: n the number of turns on the armature, S the transverse section of the armature, B the induction produced in the armature core by the permanent magnets, B_f the induction in the armature core at the moment of closing the circuit, L the self-induction of the winding *supposed to be constant.* It is now shown that it is not necessary to assume that L is constant, and that the same formula holds with L denoting the instantaneous value of the self-induction for the value of B at any given instant. The note concludes with some calculations of the torque exerted on the armature. A. J. M.

272. *Suggested Amplification of Heating Rules for Electrical Machinery.* **M. Vidmar.** (Elektrot. u. Maschinenbau, 36. pp. 49–52, Feb. 3, and pp. 64–66, Feb. 10, 1918.)—It is suggested that existing rules concerning the heating of electrical machinery impose severe and unnecessary restrictions upon designers; do not accomplish their aim; and do not fully protect the purchaser. It is difficult to measure the temperatures which really determine the danger-point. If the max. (not the mean) temperature at any point in a cotton-insulated winding exceeds 105° C. there is danger of burning. Rules and tests should refer to the max. temperature which may exist at one point only in the winding. The margin between max. and mean temperature must not be too great, or progress is retarded and economical design is impossible. Mean temperature-rise is easily measured by the increase in electrical resistance, whereas the point of max. temperature cannot readily be determined, neither is it accessible for measurements. Clauses relating to mean temperature-rise should be retained, but they should be supplemented by limiting the temperature difference between the points of max. and mean temperature.

Instead of considering an infinite number of heat-flow lines leading from all depths in the winding to the surface, the author imagines the whole winding to be a homogeneous body through the interior of which the source of heat is distributed uniformly. It is comparatively simple to ascertain and deal with the hypothetical "replacement" body in all practical cases. The

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author develops his method in detail and shows what assumptions are made and under what conditions the results may be applied.

Impregnated coils are used in practically all modern electrical machinery, and the internal thermal conductivity of such coils is about 8½ times that of plain cotton-covered wires and 1⅛ times that of shellacked cotton.

Besides transformer and field pole coils there are slot-wound coils to be considered. In such coils, heat-transfer from the interior of coils to the surface is less important, heat passing along the slots to the ends of the windings. There is little temperature-difference from wire to wire across the section of the coil, but there is a considerable gradient longitudinally from the centre to the end of the coil.

Proceeding on the above lines the author calculates the mean temperature of the interior of a winding, and concludes that if we take the mean internal temperature gradient to be half the maximum no unduly favourable assumption is made. If the max. internal excess temperature can be taken to be never greater than twice the mean, the latter may be made the basis of rational rules in place of the arbitrary rules hitherto enforced. The electrical-resistance method of measuring the heating of windings does not yield a true value for the mean inner gradient of the winding. The total thermal gradient is partly external and partly internal. It varies according to no well-defined law, but the principal part of the temperature gradient is between winding and air, and surface temperatures as high as 50° C. are not uncommon on windings. Resistance measurements yield the mean total temperature gradient, and thermometer measurement gives the gradient utilised externally. The difference represents the mean internal drop, and by adding this to the resistance measurement we obtain a value for the total excess temperature which will certainly not be exceeded in actuality. The author suggests that heating rules should specify, not the permissible mean temperature of the whole winding, but the permissible difference between the doubled mean total excess temperature and the surface excess temperature. The new process gives additional security without sacrificing any security provided by the old rules.

By way of example, the case of a 10-kv.a., 10,000/390 volt 50-cycle transformer is considered. The windings are concentric, the high-tension coil is outside and an intermediate cylinder provides both electrical and thermal insulation. The temperatures mentioned below show that the transformer conforms to existing rules yet has probably a max. temperature of 109° C. which is above the danger point for cotton insulation. Max. internal temperature drop, 52 deg. C.; mean temperature drop, 35 deg. C.; surface temperature drop, 22 deg. C.; mean total excess temperature = 35 + 22 = 57° C. Maximum excess temperature = 57 + 22 = 74 deg. C., corresponding to 109 deg. C., actual temperature if the air temperature be 35 deg. C. The author's method would reveal the dangerous heating in the above case. The resistance measurement would indicate a mean excess temperature of 52 deg. C.; thermometer measurement would show 22 deg. C. excess temperature on the surface. Then 2 × 52 − 22 = 82 deg. C. whereas the permissible difference between the limiting temperature 105° (for cotton) and the atmospheric temperature 35°, is 70 deg.

In addition to the insulation on the wires themselves, each 1 mm. of coil insulation requires about 1 deg. C. temperature gradient when the radiation is 1 watt per dm.². This factor is discussed in the original and the suggested modified rule is compared with the basis of rating now generally employed

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in oil-cooled transformers. Much metal might be saved in large transformers and generators by adopting the new rating, and, at the same time, a reasonable margin of safety would be secured in small machines. R. E. N.

273. *Zigzag Leakage in Induction Motors.* **K. Sachs.** (Elektrot. u. Maschinenbau, 86. pp. 14–18, Jan. 20, 1918.)—The zigzag leakage in induction motor windings is calculated on the lines of a former article [Abs. 150 (1916)] by considering the difference flux that is produced by the stator and rotor amp.-turns. These amp.-turns are evaluated for various characteristic moments by replacing the polyphase windings by equivalent single-phase windings lying in slots that are unequally spaced so as to imitate the effect of the unequal currents flowing in the different phases of the windings at the moments considered. A. J. M.

274. *Compensation of Induction Motors.* **H. Nehlsen.** (Elekt. Zeits. 88. pp. 584–587, Dec. 13, and pp. 593–596, Dec. 20, 1917.)—The compensation of the power factor of induction motors has been carried out by phase-compensators of three types: (*a*) those in which the compensation is practically independent of the load, and continues whether the induction machine acts as a motor or a generator, (*b*) those in which the compensation ceases when load is put on to the machine and is only obtainable when the induction machine acts as a generator if the compensating machine is reversed, and (*c*) those in which the compensation ceases when load is applied and compensation for the case in which the induction machine acts as a generator is not attainable. The article describes a new form of compensator that has the characteristics as stated under (*a*), but does not suffer from the defects of the separately excited machines. It has a series excitation, as the compensators of type (*b*), but differs from these by being able to self-excite the secondary circuit independently of the load on the induction machine. This is effected by adding an auxiliary winding on the stator. This winding may be displaced by various angles from the main winding, and it is suggested that it may be conveniently placed in the slots that are often provided for the commutating winding. It is shown that by suitable design self-excitation may be obtained in the secondary circuit, with the result that the machine is compensated also at no-load. The theory of such compensators is worked out, and it is concluded that they are applicable to induction motors that run light for considerable periods, and also to induction motors with slip-regulators as used with flywheels for driving rolling mills. Such rolling-mill equipment may be arranged to be driven by a motor with independent phases and 6 slip-rings, one set of slip-rings being connected permanently to the variable liquid resistance, and the other set being able to be connected either to the exciting machine for running or in delta connection (with disconnected exciting machine) for starting up. This has the advantage that the rotor can be designed for higher voltages, and that the starting currents in the rotor are thus reduced. The self-excited asynchronous machines with direct-coupled self-exciting exciter may also be used as a phase-regulator in place of the synchronous machines commonly used for this purpose. The advantage gained is ease of starting and of regulating the value of the leading current supplied. A. J. M.

275. *The Unsteady Regime of the Transformer.* **V. Voluinkin.** (Reprint [25 pp.], 1916, from the Proceedings of the Polytechn. Inst. Peter the Great.)—After a review of the literature on this subject, and an explanation of the nature of the rush of current, the author expounds a new graphical present-

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ment of the unsteady current, and at the same time sets out the regular selection of the magnetic curve. Special means—simplicity and the absence of subsequent approximations—render it suitable for determining the starting resistances for an unloaded transformer or for a lift electromagnet. The author confirms his theoretical investigations by oscillograms taken on no-load. The theoretical and the actual curves differ in merely a small way.

E. O. W.

276. *Armature Reaction in Rotary Converters.* **G. Badey.** (Rev. Gén. d'Él. 3. pp. 163–170, Feb. 2, 1918.)—The armature reactions of the direct current and of the alternating current flowing in the winding of a rotary converter do not completely balance. If I_d and I_a represent the values of the direct and alternating currents respectively, and n the number of turns on the armature, the d.c. amp.-turns have a m.m.f. per pole distributed round the semi-circumference in the form of a triangle of max. height $nI_d/4$. If there are q phases, each phase produces a sinusoidal field of max. value $nI_a\sqrt{2}/q$. Their combination produces a rotating field of max. value $nI_a\sqrt{2}/\pi$ per pole. If q is infinite this latter quantity may be written $(nI_c/4) \times (8/\pi^2)$. The alternating m.m.f.'s per phase have a rectangular distribution and the harmonics cancel for $q = \infty$. In this case there remains the triangular field and the stationary sinusoidal field, and the excess of the a.c. amp.-turns over the d.c. amp.-turns in the axis of the brushes is $(1 - 8/\pi^2)nI_d/4 = 0{\cdot}19nI_d/4$. The average value of the d.c. field is $nI_d/8$, and that of the a.c. field is $(16/\pi^2)nI_a/4$. These values are not exactly equal, and the mean value of the a.c. field exceeds that of the d.c. field by 1·8 %. If the number of phases is finite, then harmonics appear in general in the resultant reaction of the armature. These harmonics vanish for the orders $2qa \pm 1$ when q is uneven and $qa \pm 1$ when q is even, a being a whole number. The harmonics decrease with an increase in their order, and as a result it appears that 8- and 9-phase machines are preferable to other types, including 12-phase machines. The article concludes with a number of diagrams showing how 6-, 8-, and 9-phase rotaries may be fed from 2- and 3-phase supply circuits.

A. J. M.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

277. *Stray Power of a Transmission Line.* **D. D. Ewing.** (El. Rly. J. 51. pp. 95–97, Jan. 12, 1918.)—The article describes tests made on the transmission line of the Fort Wayne and Northern Indiana Traction Co. The line has a length of 115·4 miles, and is operated at 88,000 volts, 3-phase at 25 cycles per sec., and consists of three No. 2 (B. & S.) copper wires forming an equilateral triangle with a spacing varying between 36 and 72 in., the average spacing being estimated at 60 in. The line is supported by pin insulators on wooden poles spaced 100 ft. apart. Sectionalising switches enable the line to be divided into 10 sections. The current and power input to various lengths of the line were measured on the low-tension side of the step-up transformers, and the actual charging currents calculated for each length of line by subtracting vectorially the exciting current of the transformers from the total current measured. The total current decreased at first to a minimum value as the length of the line was increased, and then rose steadily as the line length was further increased. After correction for the exciting current of the transformers the calculated charging current was found to increase proportionally to the length of the line. With the values of the current so obtained and reduced to their corresponding high-tension values, the copper losses in the line were computed by using the known value of the resistance of the line. These losses were subtracted from the losses measured by wattmeter, and the difference gave the line-leakage loss, which amounted to 0·106 kw. per mile. A. J. M.

278. *The Unification of Frequencies.* **U. Del Buono.** (Elettrotecnica, 5. pp. 38–45, Feb. 5, and 58–63, Feb. 15, 1918.)—In view of a more rational utilisation of the power of the hydroelectric plants in Italy, it would be desirable that they should be connected in parallel, so as to help one another during the periods of maximum demand for some of them. This mutual assistance will be of still greater importance when the great national electric power main connecting all the hydroelectric plants throughout the country is realised, as the periods of low water for the installations of the North coincide with the periods of high water for those of the South, and *vice versa.*

The only difficulty for the realisation of this plan is the difference in frequencies of the different plants. Apart from the frequencies of 16 and 25 cycles, which are exclusively reserved for traction, three different frequencies are used in Italy: 42, 46, and 50. The Associazione Elettrotecnica Italiana some time ago appointed a commission for studying the problem of the unification of frequencies. The present article is the report of this commission, of which the author is the president. A map of the frequencies has already been published by this commission in Sept. 1917, and also in "L'Elettrotecnica." The author studies in detail the influence that a change of frequency has upon the prime movers (piston engines, steam and water turbines, etc.), the alternators, transformers, electric mains, motors, and upon the machines energised by these motors. The possibility of the installation of frequency changers connecting the different plants is also considered. Many diagrams showing how the efficiency, the power,

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the power factor, etc., vary when an apparatus works at a frequency different from that for which it is constructed, illustrate the article. It appears that the adoption of the frequency of 50 cycles or of that of 46 is the best solution of the problem, but the definitive solution will depend not only upon the technical discussion of the problem, but also upon the commercial, financial, and political discussion. E. B.

279. *The Improvement of the Power Factor.* **G. Sartori.** (Elettrotecnica, 5. pp. 70–75, Feb. 25, 1918.)—The purpose of this article is that of explaining some points of a former article [Abs. 65 (1918)] in which the author demonstrated that in all cases it is economically advantageous to employ phase-advancing devices. The author describes the static condensers of the British Insulated and Helsby Cables, Ltd., and the Miles-Walker phase-advancing machine. Of the latter an elementary calculation is given in order to find out its fundamental dimensions.

The improvement of the power factor of electric lines is of such importance that at this moment the problem of taking the power factor into account, when charging for the energy, is being discussed by several electrical associations of the world. The author agrees with Boucherot in the view that the price of energy must be proportional to $A \times VI \cos\phi + B \times VI \sin\phi$, and not to $A \times VI \cos\phi + B'VI$ as proposed by Arnò. E. B.

280. *Large Generating Stations.* **M. Seidner.** (Elektrot. u. Maschinenbau, 36. pp. 2–4, Jan. 6, and pp. 16–18, Jan. 13, 1918.)—The author considers in detail the composition of total current costs and gives general curves and formulæ for the variable and total costs in any particular case. With increasing load factor, the total cost per unit decreases hyperbolically towards the "fuel cost," whereas at low load factor fixed charges are of chief importance and fuel costs may almost be neglected. At high plant load factor, fuel cost is the principal consideration, whereas the lower the load factor the less important becomes cheap equipment. The advantage of large compared with small generating sets in point of lower first cost per kw. are well known; the author gives typical data illustrating this point. Labour costs per unit may be 20 times as great in a small station as in a large one. Some reserve plant is essential, but the proportion may be lower (and the plant factor therefore higher) in a large station than in a small one. A large station can accept all industrial loads, whereas a small station dare not connect loads exceeding a fraction of its own plant capacity. The problems of cheap coal supply and the possible operation of a private colliery are best solved by a large station. Whereas the thermal efficiency of a small hand-fired boiler rarely exceeds 50 to 60 %, that of a large boiler with machine stoking may be 88 %. Finally, the steam consumption of a 50,000-h.p. turbine is about 5 kg. per kw.-hr., compared with 10 kg. per kw.-hr. for a 500-h.p. machine. A detailed numerical example is given comparing stations with a 300-h.p. crude-oil engine and a 9000-h.p. steam turbine respectively. It is concluded that the total cost of current is 5 times as great in the smaller station, which has principally a lighting load, as in the larger station, which serves many small and large motors.

The decrease in capital cost per h.p., and the increase in efficiency ultimately, become very gradual if the capacity of the station considered be very great. Also the advantage derived from reduction in stand-by losses and in wages by centralisation becomes relatively less as the size of station increases. The author devotes a considerable amount of attention to the question as to how far centralisation may profitably be carried. In Germany and Austria a

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good deal of interest has been taken in schemes for State participation in electricity supply. In Bavaria it is proposed to develop the Walchensee scheme; in Saxony two large stations are proposed to utilize brown coal; and there are ambitious proposals for large stations with 100,000-volt transmission lines in Prussia. The author considers that in most cases it is not feasible to supply a whole country economically from one vast network. Unless the "consumer-density" is very high the limit of geographical area is soon reached beyond which capital charges on an extensive distributing network outweigh the reduced current costs attained by centralised generation.

A reasonable compromise and a vast improvement on present conditions would be to supply all power requirements in individual cities from single stations. Statistics indicate that the mean capacity of all prime movers in a large town is between 40 and 60 h.p., so that where the total installed h.p. is 100,000 there will be about 2000 prime movers. These might obviously be replaced by four 25,000-h.p. turbines in a central station. The efficiency of the average private industrial power plant is particularly low. Difficulties in the supply of labour and materials during the war have done much to extend appreciation of the advantages of central-station service.

An example is given comparing in detail the power costs for a 1000-h.p. private plant and for supply taken from a 10,000-h.p. central station. It is shown that the central station could supply on competitive terms and yet realise 12 % profit. The consumer would reduce his investment by purchasing energy "ready made" and the station would derive increased income and at the same time reduce its generating costs. The higher the price of coal, materials, labour, and freight the greater the saving effected by taking energy from a central station. It is a matter of national importance to effect at least "local centralisation," and the author suggests that State assistance would overcome difficulties due to differences in the kind of current used at present, and to modification necessary in existing supply rights. Manufacturers would benefit from standardised supply system and equipment. R. E. N.

281. *Standardisation in South African Electric Supply Systems.* **J. Roberts.** (Electrician, 80. pp. 668–669, Feb 8, 1918. Abs. of paper read before the S. African I. E. E.)—The author recommends 3-phase current as a basis of standardisation, and after the discussion of the paper, resolutions agreeing to certain standards were passed. According to this plan, 50 ∿ would be the periodicity: 415, 3300, and 6600 volts the generating pressures: the supply pressures would be 240, and 480 on the 3-wire system, and 240 and 415 on the alternating-current 4-wire with three phases. The transmission pressures would be 3300, 6600, and 11,000 volts. Armoured cables, suitable for laying direct in the ground, should be used; and it was considered desirable that the various kinds of mains in use should be readily distinguishable from the outside without cutting the cable; this could be done either by varying the width of the standard tapes or by introducing a steel wire or wires in the jute serving. W. H. S.

282. *Operating Costs of Electric Elevators.* **C. W. Naylor.** (Power, 47. pp. 188–189, Feb. 5, 1918.)—The author gives the results of ten years' working, ending Dec. 31, 1916, of 50 worm-gear, drum-type elevators having a 150- to 280-ft. lift and running in passenger service at a max. speed, loaded, of 350 ft. per min. They are all of the over-

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head drum type, overbalanced as to counterweight, and are operated on direct current at about 226 to 230 volts with magnet control and steel guide rails for cars and counterweights, of which there are two sets, one for the drum and one for the car. The cables are ¾ in. in diam. running over idler sheaves and drums of approximately 46 in. diam. The 2 car-counterweight cables pass directly over the idler sheave, while the car-hoisting cables wind on the drum as the drum-counterweight cables unwind, and *vice versa*. The cars weigh approximately 4000 lbs. each and the double counterweights 5000 lbs. The drums are driven by double, or fore-and-aft, bronze worm gears meshing with steel worms on an extension of the armature shaft, with the magnet brake on this shaft between the armature and the worm. The armature revolves at 850 r.p.m. on high speed, the drums meanwhile turning at about 80 r.p.m. The labour shown is for the wages of the maintenance and repair mechanics. Each man has charge of 12 cars, oiling, cleaning, adjusting, and effecting ordinary repairs. Two extra men make heavy and extraordinary repairs, *e.g.* installing armatures, greasing guides, and putting on cables. The item "miscellaneous" includes leather for brakes, copper rivets, babbitt, bolts, screws, etc. Armature includes rewinding and a few field-coil renewals. Repairs includes brushes, controller discs, contact lugs, carbons, and such material as would be purchased from the manufacturer of the machine used mostly in keeping up the controller boards. Each passenger car travels about 18 miles per day, making for the year of 310 days a total of 4080 miles. Dividing the average annual cost per car by this mileage gives a maintenance cost of $0·0387 per car-mile, of which about 75 % is for labour, and 25 % for materials and supplies. The figures for the maintenance costs in dollars over 10 years for 50 electric elevators are as follows :—

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	Total.	Average.
Oil	93	93	93	68	68	110	110	78	92	52	857	86
Grease ...	8	16	16	25	26	34	28	29	31	9	222	22
Repairs ...	425	1105	618	465	467	603	119	40	39	96	3977	398
Armatures ...	1060	1160	461	1148	935	540	918	580	660	362	7824	782
Cables ...	—	467	188	323	140	174	213	316	360	1012	3193	319
Labour ...	5000	5000	5525	5525	5525	6375	6375	6450	6450	7650	59,875	5988
Miscellaneous	110	59	307	238	344	170	269	84	270	92	1943	194
Total	6696	7900	7208	7792	7505	8006	8032	7577	7902	9273	77,891	7789
Per Car ...	134	158	145	156	150	160	161	151	158	185	1558	156

C. A.

283. *Report of the Committee for the Interconnection of the Lancashire and Cheshire Electricity Supply Systems.* (Electrician, 79. pp. 814–816, Aug. 24, 1917.)—This second report of this Committee outlines the constitution of the proposed Joint Board and the basis for allocating charges.

284. *Suggested Safety Rules for Electrical Equipment in Bituminous Coal Mines.* **H. H. Clark** and **C. M. Means.** (Bureau of Mines, Techn. Paper No. 138. [26 pp.], Washington, 1916.)—These rules deal with American practice ; the original pages should be consulted by those interested. L. H. W.

285. *A General and Quick Method for Calculating Masts.* **M. Semenza.** (Elettrotecnica, 5. pp. 79–81, Feb. 25, 1918.)—In a former article [Abs. 802 (1917)] the author has set forth a quick method for calculating a mast of square cross-section. In the present article he develops his method for rectangular-based masts. Adopting the same method as for square-based masts, a system of 7 equations among 7 unknown quantities is obtained, the

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solution of which would require a 8-dimensional diagram. But, assuming that the ratio between the two sides of the pole be known, this system of equations is split off into two separate systems, each of four equations among four unknown quantities, like those for square-based poles, and these can be solved in the same manner. The method of "false position" allows then of finding the value of the ratio aforesaid, two or three attempts being generally sufficient to determine with good approximation the values of the sides of the pole. A practical example of the method is subsequently given. E. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

286. *Electrification of Main Lines in Austria.* (Elektrot. u. Maschinenbau, 85. pp. 20–22, Jan. 13, 1918.)—Utilisation of water-power for electrification of the State railways was first studied in 1891, but the Ministry of Railways did not take up the whole matter systematically until 1905. The present notes outline the State programme in the problem of utilising all available water-power in the Alpine district and in Dalmatia, and electrifying as much as possible of 4400 km. of State and 1800 km. of private railways south of the Danube. A comprehensive study has been completed of all the geological, hydraulic and climatic factors involved; as well as of the alternative schemes for utilising and dividing the available water-power. During this period the Railway Department has developed 16 large water-power schemes of 70,000 minimum and 150,000 max. h.p. Opposition has been offered to speculative enterprises and to schemes involving the splitting up of valuable falls. In the original report of the Commission appointed to consider the electrification of the State railways, particulars are given concerning electric railways in Germany, Switzerland, France, Italy, Russia, Sweden, and Norway, particularly in respect of the State measures taken to secure technical and financial efficiency.

No agreement was reached either at the International Railway Congress (Berne, 1910) or by the Union of German Railway Administrations (1911) concerning the best system of traction to be adopted. Since then all three systems (d.c., 3-phase, and 1-phase) have been developed to such an extent that any one of them can be used satisfactorily in main-line electrification. Conditions in respect of electrification possibilities on a number of routes are reviewed briefly and a table is given summarising technical data for a number of d.c. and single-phase a.c. railways (total length 492 km.) taking current from hydroelectric stations.

For strategic reasons the military authorities require that certain converted steam lines should be capable of being restored to steam working without delay. This stipulation involves serious increase in investment. It is concluded from German and other experience that single-phase working at 15,000 volts line pressure and 12 to 16⅔ cycles per sec. is the best system to adopt, and it is proposed to use it on the Arberg line if the difficulties of obtaining materials can be overcome.

In a review of the development and prospects of water-power in Austria, it is stated that of 8 million h.p. capable of being used effectively in the Alpine district only about 8 % has been developed, owing to a variety of causes amongst which are the high efficiency of steam plant the imperfect development of electrochemical industries, insufficient experience in building large water-power stations, and preference of investors for schemes yielding

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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more rapid return. The coal shortage has attracted much keener interest in water-power. At present the State Railway Department has control over 18 concessions for water-power totalling 164,000 h.p. (annual mean). The paper concludes with a summary of the policy and measures recommended for adoption. R. E. N.

287. *The Electrification of Railroads.* **F. H. Shepard.** (El. Rly. J. 51. pp. 4–7, Jan. 5, 1918.)—This article is intended to show the advantages to be expected from further electrification of the railways of the United States. It is claimed that it would increase the capacity of the existing tracks and terminal facilities; that it would decrease the consumption of fuel; that it would reduce the amount of labour required for operation and maintenance. It is considered that in consequence of the war, greater economy will be necessary, and at the same time an expansion of present systems will be desirable in order to deal with an increased volume of traffic. The increasing capacity and efficiency of hydroelectric and steam generating plants tend to increase the relative economy of the electric locomotive as compared with the steam locomotive. W. H. S.

288. *Life of Current-collecting Contact Pieces.* (Elekt. Zeits. 39. p. 17, Jan. 10, 1918.)—A large table sets out the principal results of questions addressed to Swiss railways concerning the life of various forms of contact pieces for electric railways. The results are not directly comparable, since the contact pieces are not of equal breadth, of equal section, or of the same raw material. The principal deductions are as follows:—A. The condition of the conductor line is very important, and it should be zigzagged to prevent formation of grooves in the contact pieces. The max. life of contact pieces for 1- and 3-phase high-tension lines is 45,000 km. (average 40,000 km.) with pieces of $\vee$-section. On low-pressure lines the max. life is 80,000 to 100,000 km. (average 80,000 km.) with U-section contact pieces. Lubrication of the line 2 or 3 times a year with consistent fat reduces wear and does something to reduce the formation of ice on the line. On some railways the conductor lines are freed from ice by hand; in other cases cleaning gear is mounted on special wagons, or the line is heated electrically before running is commenced for the day. Ice deposits are unfavourable to satisfactory collection of current, particularly at low voltage. B. The life of contact pieces decreases with the current collected. The heaviest currents concerned in the cases tabulated are 250 to 500 amps. in low-voltage lines and 130–150 amps. in high-tension lines. C. Aluminium contacts are more durable than those of triangular brass tube, and brass contacts generally grip the line wire to a greater extent than Al contacts. In the latter connection drawn metal is better than cast metal. A good alloy for contact pieces is Al with 5 or 6 % Cu. The sections most in use are the W-section for railways and the U-section for tramways; the contact piece is always lubricated by filling the grooves with stiff fat mixed with flake graphite. D. Wear of contact pieces is more rapid the greater the bearing pressure (which is generally from 2½ to 4 kg.), and is greater the heavier the current to be collected. The max. bearing pressure of the contact bow is 5½ to 6 kg.; the automatically reversible collector necessitates higher bearing pressure apart from other considerations. E. The life of contact pieces decreases as the running speed increases. F. Maintenance costs are not of primary importance, but they are to be considered owing to the present high cost of raw materials. The conductor line should be kept in good maintenance and the bearing pressure of the contact bow should be uniform and adjustable. R. E. N.

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289. *Welded Rail Joints.* **M. Schreiber.** (El. Rly. J. 51. pp. 190–192, Jan. 26, 1918.)—Describes a new method of welding tramway rails by the electric arc, introduced by the Atlantic Welding Co., and used at Newark, N.J., where some 3000 ft. of track, consisting of new grooved girder rails, has been thus welded. Fishplates are placed on each side of the rail, the top and bottom of the former being planed in such a way as to facilitate the welding. A bar of special composition is then clamped against the fishplate, which has a controlling effect on the arc and also holds the welding metal in place. Suitable guide rods are attached to the joint apparatus, greatly facilitating the making of the weld, and securing fairly uniform results. The apparatus when in position does not interfere in any way with the running of the cars. Current is supplied by a motor-generator mounted on a truck, the outfit weighing about 1100 lbs., the motor taking about 88 amps. from the trolley line. The weld is affected by means of a carbon electrode in the usual way, the necessary additional welding material being supplied by placing a soft steel rod in the groove provided between the rail and the edge of the composition bar, which when welded in place leaves a tough close-grained weld of good quality about ½ in. deep. The time taken to complete a weld is about 20 mins., and the energy required about 7 kw.-hrs. Tests show that the hardness of the rail is practically unaffected by the welding, and that the tensile strength of the joint is greater than that of the plates themselves. A transverse test made on a 4-ft. span and with a concentrated load of 50 tons at the centre showed less than ¼ in. set. Important features in favour of the method are low cost, convenience of installation, and minimum disturbance of paving. R. J. W.-J.

290. *The Couple-gear System of Electric Traction.* (Automotor J. 23. pp. 156–159, March 1, 1918.)—In this system each wheel of the vehicle consists of a rim uniting the peripheries of a pair of shells that turn on ball bearings on sections of a non-rotary shaft, which is pivotally mounted on the end of the corresponding axle and which includes an electric motor arranged between the shaft-sections. The conductors supplying current to this motor pass through a passage in the inner section of the non-rotary shaft. The armature of the motor drives, through differential gear, two pinions arranged coaxially on opposite sides of the motor and acting on gear wheels mounted on the inner sides of the wheel-shells respectively. By this means the motor and gearing are entirely enclosed in the wheel, the power is applied peripherally to both shells at two diametrically opposite points near the wheel rim through single direct reduction gearing of, *e.g.*, 25 to 1 ratio, so that mechanical efficiencies of 93 to 97 % are obtained. Also all four wheels of a vehicle can be used for steering and driving, which enables the vehicle to climb hills easily, to turn in confined spaces and to be manœuvred without slipping on greasy surfaces. C. A.

291. *Electric Battery Locomotive.* (Engineer, 125. p. 213, March 8, 1918.)—An electric battery locomotive is described, built by the North Staffordshire Railway Co., for service at the Oakamoor Copper Works, of T. Bolton and Sons, Ltd. The locomotive has wheels of 3 ft. 1 in. diameter, with a wheel base of 8 ft., the total weight being 17 tons. It is equipped with two motors, being one per axle. Each motor is rated to give 27 b.h.p. with 160 volts and 41 b.h.p. with 250 volts, these being one-hour ratings, with a temperature-rise not exceeding 75 deg. C. The locomotive is capable of hauling a load of 90 tons at 10 miles/hr. on the level. Ordinary series-parallel control is pro-

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vided. Great care has been taken to secure efficient ventilation of the battery. The equipment in the cab includes an automatic circuit-breaker and D.P. change-over, charge and discharge switch. The battery consists of 108 cells by the D.P. Co., the positive plates being of the Planté type, and the negatives of the box type. The battery boxes are of teak and are lead-lined, fitted with lids, vent plugs, etc. The capacity of the battery is given as 30 amps. for 10 hours, and 150 amps. for one hour, and the total weight of the battery is 6 tons 8 cwt. W. R. C.

ELECTRIC LAMPS AND LIGHTING.

292. *Use of Glow-lamps for Projection Apparatus.* **O. Kruh.** (Elektrot. u. Maschinenbau, 35. pp. 573–575, Dec. 2, 1917.)—The author investigates, by the aid of formulæ, the characteristics of glow-lamp filaments, lending themselves to optical projection. A table of intrinsic brilliancies of the chief illuminants is given. Improvements have been made by mounting filaments as adjacent bars close together, and increasing the diam. so as to use larger currents. The effect of altering the space between adjacent filaments is discussed. The chief difficulty in making lamps for very high currents has hitherto been the mounting of the leading-in wires. This the author states has been overcome and lamps consuming up to 200 amps., giving 30,000 to 40,000 c.p. (Hefner) and working at 0·25 watt per c p. (Hefner), have been made. The c.p. attainable is limited only by the size of the bulb, but up to 100,000 c.p. could be obtained if need be. The effective intrinsic brilliancy of the source can also be increased by placing a mirror behind it, forming an image of the filaments in the spaces between the successive bars. In this way an intrinsic brilliancy of 70 c.p. per mm.^{2}, approaching that of the carbon arc, can be secured. J. S. D.

293. *Rules concerning Supply and Decay of Tungsten Lamps.* (Vereinig. d. Elektrizitätswerke, Mitt. No. 204. Elektrot. u. Maschinenbau, 35. pp. 19–20, Jan. 13, 1918.)—The Lighting Rules Committee of the Union of Electricity Works has agreed with representatives of tungsten lamp manufacturers concerning rules which will govern the delivery and acceptance of tungsten lamps after the war. The rules apply only to vacuum lamps with plain (*not* spiral) filaments and to standard gas-filled lamps. The lamps must be for burning in parallel and must have clear pear-shaped or spherical bulbs. Rules 4 to 6 apply only to batches of lamps of the same voltage, wattage, and general construction, the minimum number of lamps in each consignment being 100 up to 100 watts; 50 over 100 watts and up to 300 watts; or 25 over 300 watts. The marking of lamps is to state the watts, volts, and mean spherical c.p. Lamps will be specified by wattage, standard sizes being 10, 20, 25, 40, 60, and 100-watt vacuum lamps; and 40, 60, 75, 100, 150, 200, 300, 500, 750, 1000, and 1500-watt gas-filled lamps.

Rules 4–6 state that lamps will be tested for wattage, mean spherical c.p., mean spherical c.p. per watt, and mean depreciation of candle-power at the voltage for which they are marked. The permissible variation in wattage is 2 watts low and 1 watt high, and the mean value of power consumption may be 8 % lower or 4 % higher than the nominal (marked) value; in individual lamps the latter variations may be −12 % and +8 % respectively. The mean candle-power may vary −15 % to +10 % (or at least 2 c.p.) from the values given in the original for various wattages. The mean spherical c.p. per watt may vary 10 % from the value given by the standard wattage and candle-power data. Lamps not complying with these requirements may be

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rejected, but a whole consignment may only be rejected if more than 10 % of the lamps fail to pass. The mean spherical c.p. is to be measured by spherical photometer. Depreciation in c.p. will be determined by measurements at 0, 200, 500, 800, and 1000 hours in the case of vacuum lamps and at 0, 200, 500, and 800 hours in the case of gas-filled lamps. The number of lamps to be tested from each consignment is at least 12 up to 100 watts and at least 8 in the case of lamps exceeding 100 watts. Permissible deterioration in c.p. is as follows: 15 % after 100 hours in vacuum lamps up to 25 watts for 100–130 volts or 40 watts for 200–230 volts; 20 % after 1000 hours in vacuum lamps of higher wattage; 20 % after 800 hours in gas-filled lamps. Lamps which fail before 1000 or 800 hours respectively are to be ignored when determining the decay of candle-power, but if more than 2 vacuum (or 3 gas-filled) lamps fail prematurely in each dozen lamps tested, up to 100 watts (or more than 2 in each 8 gas-filled lamps over 100 watts), a double number of lamps may be tested, and if the result is again unfavourable the whole consignment may be rejected. R. E. N.

294. *"Overshooting" in Metal-filament Lamps.* **C. J. Berry.** (El. World, 71. pp. 459–462, March 2, 1918.)—The author investigates the degree and duration of "overshooting" (*i.e.* excess current) which occurs when tungsten lamps are first connected, owing to the resistance of the cold filament being low compared with its resistance when incandescent. The main factors influencing the initial phenomena are lamp-filament resistance, line resistance and reactance, and the regulation of the source of supply. The lamps used in the present investigation were of the 105–125-volt class and included untreated carbon filament lamps, vacuum tungsten lamps, and all sizes of gas-filled tungsten lamps between 75 and 1000 watts. Three sources of energy were used in turn, viz. a 7·5-kw., 120-volt d.c. generator; an 80-amp.-hr., 120-volt storage battery; and a 115-volt 60-cycle lighting circuit.

Theoretically, the current flow varies inversely with the filament resistance if the voltage remains constant, but actually there is self-induction in the line and an increased resistance drop. Also the voltage regulation of the apparatus supplying energy must be considered. All of these factors reduce the degree of overshooting. Inductance effects in the lamp, skin effect, and cooling of the filament by gas and leading-in wires have probably little influence on the current flowing during the initial period. Line reactance retards the rate of current-increase, and as the filament becomes hot its rising resistance quickly reduces the current flow. The max. current is reached in from 4×10^{-4} sec. to 8×10^{-8} sec. after the switch is closed, and the normal operating current is reached in from 0·1 to 0·2 sec. The initial rise in current is greater if the generator be sufficiently large to absorb the load without showing a decrease in voltage.

The ratio of hot to cold filament resistance is approximately as follows:—Untreated carbon, 0·5 : 1; metallised carbon, 1·5 : 1; tantalum, 6·5 : 1; vacuum tungsten lamp, 11·5 : 1; gas-filled tungsten lamps (75–1000 watts), 14·6 : 1. The ratio of initial max. current to normal current is never so high as the resistance ratio. In a 75-watt gas-filled tungsten lamp, the max. initial : normal current = 12 : 1, but the ratio decreases with increasing lamp wattage and is only 7 : 1 for 1000-watt lamps. This is due to the low initial resistance of the filament causing current to increase very rapidly at first, thus producing relatively high reactance and line-resistance drop. As a result, the effective voltage at the lamp terminals during the critical initial period is reduced to a low value in the larger lamps. To obtain by calculation a close

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approximation to the actual lamp p.d. would require knowledge of the constants of the entire circuit, as well as complete knowledge of the behaviour of the lamp when subject to rapidly changing current. The main point is that there is inherent regulation in all circuits which prevents the current from rising to the theoretical 14·6 times the normal value; the decrease in initial lamp voltage is much greater than the calculated line drop due to the max. current flowing, and is probably due to inductive reactance drop.

Tests with a 1000-watt gas-filled lamp on 60-cycle alternating current show that the time taken to reach normal current was the same as with direct current. The amount of overshooting was 500 % when the lamp was thrown in circuit at the zero of the voltage wave and 600 % when connected at the peak of the voltage wave (compared with 700 % on direct current). The current reaches its maximum before the voltage peak, hence max. overshooting occurs when the lamp is connected just before the voltage reaches its peak value. The max. initial current depends on the magnetic state of the transformer when the switch is closed, and this depends upon the point in the cycle at which the circuit was previously opened. Slightly less overshooting occurs with vacuum lamps than with gas-filled lamps because the filament temperature of the latter is higher. Fuses or circuit-breakers should not open when gas-filled lamps are connected singly or in "banks," provided that the protective apparatus is of correct rating and has a small time-element.

R. E. N.

295. *Report of Committee on Nomenclature and Standards of the American Illuminating Engineering Society* (1917). (Am. Illum. Eng. Soc., Trans. 12. pp. 438–448, Dec., 1917.)—The report comprises 61 definitions of terms employed and paragraph 62 consists of a list of photometric units and abbreviations adopted. L. H. W.

296. *A New Industrial Lighting Unit.* **W. Harrison.** (Am. Illum. Eng. Soc., Trans. 12. pp. 409–421; Disc., 422–424, Nov., 1917.)—The author discusses the artificial lighting of factories in relation to natural illumination. In ordinary circumstances a source may become glaring if its brightness exceeds approximately 1·6 candles per sq. in. Only the candle-flame complies with this requirement, and shading is therefore necessary. A table of intrinsic brilliancies of the chief light sources is given. In a factory, illumination of vertical surfaces is an important consideration. The author describes a special unit for factory lighting, designed to minimise glare, give soft shadows and emit sufficient light at 65° to 70° to give satisfactory vertical illumination. This unit consists of an upper reflecting hood enclosing a gas-filled lamp, the lower portion of the bulb being coated with a polished metal surface reflecting light upwards into the hood. In some cases the area is sand-blasted instead of being covered by the opaque reflecting metal. Polar curves of various units of this type, and data showing the flux reflected, are presented, and a table of working intensities of illumination (horizontal and vertical) for various processes in factories is given. It is calculated that with current at 2 cents (1d.) per unit an illumination of 5–10 candle-ft. can be produced for 7·5 cents (approx. 4d.) per sq. ft. per year for a night shift of 2500 hrs. In the *discussion*, it was remarked that the silver cap should not be used in factories where there are strong fumes and liability to oxidation; in such cases bowl-frosted lamps are usually employed; suitable frosting compounds are now available which are relatively easy to clean. J. S. D.

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TELEGRAPHY AND TELEPHONY.

297. *Increasing the Efficiency of Telegraph Lines.* **O. Srnka.** (Elektrot. u. Maschinenbau, 35. pp. 621–627, Dec. 30, 1917.)—The author refers to a previous paper of his [Abs. 181 (1916)] on the same subject. The present paper deals very completely with the transmission of high-frequency currents over line wires, and the usual equations are established.

A comparison of impedance variations with frequency, of various iron and copper wires is given. The author also investigates at length the alteration in the line constants, *i.e.* capacity, inductance, leakance, and resistance, over a range of frequencies between 200 and 1200 per sec. for bronze and steel aerial wires and telephone cable. The current intensities for different frequencies in various classes of line are also investigated. The purpose of the investigations is to find the best conditions necessary for a form of multiple telegraphy based on differentiation by frequency, selection being accomplished by mechanical resonance. The system of n stations is to be arranged so that any one station may communicate with any other. This necessitates approximately equal current values at the range of frequencies employed, and the line constants are artificially varied to secure this.

The receiving device consists of a conical harp of steel wires of various lengths, having different oscillation constants and each tuned to one of the transmitting frequencies. Inside the conical harp is placed the core of an ironclad magnet, the external jacket surrounding the outside of the cone. Adjustable iron screws in the jacket can be moved to or from any of the steel wires so that if any frequency exists in the line, it can be made to affect its corresponding steel wire. The harp carries a microphone arranged to control a relay and telegraph instrument. When one of the wires of the harp is set in vibration, the microphone responds and upsets the balance of a Wheatstone bridge circuit, thus operating the relay. The transmitter comprises a microphone hummer with acoustic methods of altering the frequency.

If any station desires to correspond with any other, the harp wire corresponding to the desired station's frequency is adjusted to resonance, and if no signals are heard the operator knows that the desired station is disengaged.

The system does not appear to be in use. H. H. H.

298. *Electric Signalling and Control on Railways.* **C. M. Jacobs.** (Inst. El. Eng., J. 56. pp. 136–142; Disc., 142–152, Jan., 1918. Electrician, 80. pp. 556–557, Jan. 11, 1918. Abstract.)—The author divides railway signalling into two main branches: (1) Block signalling, which has to do with keeping trains on the same line of rails properly spaced. (2) Interlocking signalling, which ensures that the points over which the trains pass are properly secured, and governs movements in and about station yards and junctions.

A brief comparison is instituted between the British and American signal aspects, and the simplicity of the American three-position signal pointed out.

The indication of points and signals by means of repeaters is, the author states, not always as effective as it should be, owing to the modest appearance and delicate character of the form of indicator employed, and the author pleads for audible signals additional to the visual indications given when a signal and its controlling lever are not in agreement. Mere indication is not sufficient. In block signalling it should not be possible to place a signal in the "proceed" position, unless at the same time the signal in advance is at "stop." The paper describes an electrical system for securing this.

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In electrical systems of point detection the use of "common" conductors is deprecated.

The track circuit is stated to be ideal for the detection of anything on wheels across the rails. With a 4-ohm or 9-ohm relay and 1-volt battery, a track circuit cannot be depended upon to detect anything which does not put a virtual short-circuit on the rails. A track circuit is not reliable for a single vehicle, which, with an unclean rail, may mean a train shunt of anything up to 5 ohms. It may also fail to take care of a light engine or even a complete train. In order that track circuits should be reliable, they should be adjusted for minimum train shunts of 5, 10, and 20 ohms with infinite ballast for the following class of circuits : (*a*) those which may be acted upon by complete trains only, (*b*) those which may be acted on by a single vehicle, and (*c*) facing-point track circuits. The adoption of such higher standards demands a higher ballast resistance, possible probably by a subdivision of the track circuit, a higher-resistance relay, a higher battery resistance, and a battery having a higher e.m.f. Curves are given illustrating these points.

The author describes briefly the well-known system of automatic train control in use on the Great Western Railway. A description is also given of the electrical operation and control of gravity sorting sidings. This would require too much space to describe adequately, and the paper should be referred to.

The opinion is expressed that the token system of working single lines is, on the whole, the most satisfactory method, and in the paper is a description of a very simple type of token instrument.

The author advocates the use of power in place of primary batteries, as this would prove economical and would result in improved signalling apparatus, since current could be obtained from central batteries of accumulators in place of individual batteries of limited output.

The paper concludes with a word of caution as to the supposed infallibility of electrical signalling appliances. It is pointed out that no electrical system is absolutely fool-proof, and unless intelligently designed, installed and maintained, is only comparatively safer than mechanical systems or a code of rules.

In the *discussion*, **J. W. Pringle** advocated wider experiments with three-position signals. He agreed with the author's suggested treatment of the three classes of track circuits. It was hoped to find in automatic train control a safeguard against mistakes by engine-drivers. Any such system should not create a tendency to neglect observation of the road. A large proportion of drivers' mistakes were due to misreading signals after the distant signal had been duly observed. He advocated the extension of the control to stop-signals, the author's system only applying to the distant signal. H. H. H.

299. *Comparative Experiments on Audions.* **G. Vallauri.** (Jahrb. d. Drahtl. Tele. 12. pp. 349–398, Dec., 1917.)—A translation of the paper dealt with in Abs. 646 (1917.)

300. *Description of the Dynatron.* **A. W. Hull.** (Inst. Radio Eng., Proc. 6. pp. 5–35, Feb., 1918.)—The dynatron is a vacuum tube possessing the property of having a negative electric resistance. It belongs to the kenotron family of high vacuum hot-kathode devices. Although it resembles the kenotron and the pliotron in construction, its action is fundamentally different. The kenotron rectifier uses the unidirectional property of the current between a hot and a cold electrode in vacuum. The pliotron

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utilises the space charge of this current, which allows the current to be controlled by the electrostatic effect of the grid. The dynatron depends in its action on the secondary emission of electrons by a plate on which the primary electrons fall. It consists of an evacuated tube containing a heated filament F, a perforated anode A, and a third electrode P, called the plate. The plate must be placed near the anode in such a position that some of the electrons set in motion by the anode voltage may fall upon it. A battery

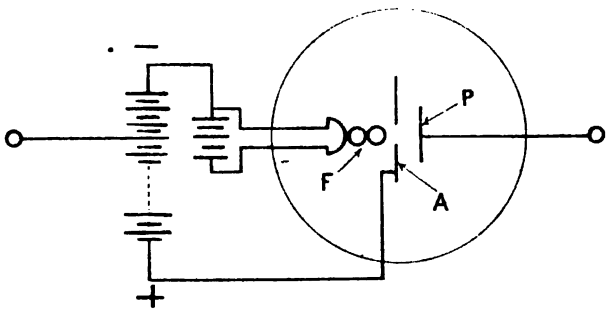

FIG. 1.

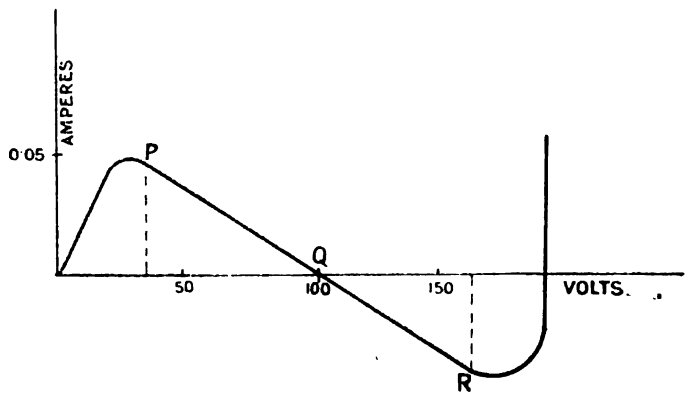

FIG. 2.

maintains the anode at a constant positive value of 100 volts or more with respect to the filament. Illustrations show that the plate is made in the form of a cylinder, and that the anode contains a large number of holes instead of one, as shown in Fig. 1. It may take the form of a perforated cylinder, a spiral of stout wire, or a network of fine tungsten wires. The filament is made of tungsten wire, and may be further provided with a heavy insulated wire along its axis, or be surrounded by an insulated spiral so as to form a "four member" tube called a pliodynatron. In action, electrons from F are set in motion by the field between F and A, and some penetrate the holes in A and reach P. If P is at a low potential with respect to F, the electrons enter P and form a current of negative electricity in the external circuit. If the potential of P is raised, the velocity with which the electrons strike it will increase, and when this becomes great enough secondary electrons will be emitted from the plate. These will be attracted to A, which is more positive than P. The net current of electrons received by P is thus the difference of the incoming primary and outgoing secondary electrons.

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If various voltages E are impressed between P and F the voltage-current relation will be as shown in Fig. 2, in which the plate current is reckoned positive when the electrons pass from the filament to the plate. When the voltage E impressed between P and F is very small, only the electrons from the most negative end of F can reach P: when E reaches about 25 volts, P receives the full primary current from the whole filament. This current remains essentially constant for all higher voltages. When E rises above 25 volts, the emission of secondary electrons from P causes the *net* current to the plate to decrease. At 100 volts the net current is zero, and above this voltage the current reverses and increases until A is no longer sufficiently positive to carry away all the secondary electrons, and the current again becomes zero and then rises rapidly to a value corresponding to the number of primary electrons. Between the points P and R the current i obeys the law $i = i_0 - E/r$, and the tube may be regarded as having a negative resistance r. The term i_0 vanishes if the battery voltage is chosen so that the dynatron current is zero. If the dynatron is connected in series with a circuit containing positive resistance, the positive and negative resistances may be equalised, and the circuit acts as a voltage amplifier. If placed in parallel with a positive resistance the arrangement acts as a current amplifier. If the dynatron be connected in series with a parallel connection of a reactance (L, R) and a capacity (C), oscillations result if $Rr < L/C$ and the damping may be made as small as desired, so that an impressed oscillation will persist for a very long time. A dynatron short-circuited by a couple of turns of heavy wire will give a frequency of about 20×10^6 cycles per sec., and frequencies as low as 1 cycle a sec. are obtainable by suitably adjusting the external reactance and capacity. The wave-form will follow the sine law if $L/C = Rr$, and will be distorted if this relation is not satisfied. Oscillograms are given to illustrate this effect. If an external e.m.f. is impressed, the forced oscillations are shown to be much greater than if the circuit contained no dynatron. If a magnetic field is applied to the dynatron in a direction parallel to the axis of the cylindrical anode an increased number of electrons are stopped by the anode and the departure of secondary electrons from the plate is impeded. This changes the characteristics of the tube profoundly. Negative currents are no longer obtained, and the negative slope of the voltage-current curve disappears as the field increases.

In the pliodynatron, already referred to, in which a grid is added, an electrostatic field is applied to control the number of electrons reaching the plate, the negative resistance being inversely proportional to the applied grid potential, and the tube becomes a powerful amplifier. It may also be used as a radio generator. If a telephone transmitter is connected between the grid and filament the arrangement may be used as a radio-telephone transmitter. The magnetically controlled dynatron may also be used for this purpose. It is shown that the dynatron may be also used as a detector and that, as low damping is attainable even with close coupling, selectivity is possible with a much more effective ratio of transformation than has been hitherto possible. The connection of a dynatron in the plate circuit of a pliotron enables the d.c. voltage amplification to be greatly increased; in a particular case the increase was from 12 to 625-fold. When inserted in the grid circuit of a pliotron detector weak signals were increased from audibility to a roar. With two pliodynatrons in series a total amplification of 10,000-fold has been obtained. A. J. M.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

MAY 1918.

PRIME MOVERS.

STEAM PLANT.

301. *Wreck of a 35,000-kw. Turbine.* (Power, 47. pp. 890–895, March 19, 1918. El. Rev. 82. pp. 841–848, April 12, 1918. Abstract:)—Describes the conditions leading up to the fracture of certain buckets and part of the casing of a 35,000-kw., 20-stage, 1500 revs. per min., 25-~ single-cylinder impulse turbine in the O Street station of the Boston Elevated Railway Co. and the damage resulting thereform. The turbine was installed a year ago, and during the trial runs on Feb. 14, 1917, the 18th diaphragm became distorted, rubbed the buckets where they join the wheels, stripped the buckets from the 18th and 19th wheels, and damaged the 18th and 19th diaphragms. The capacity of the turbine was reduced to 20,000-kw. pending repairs. After repair nineteen 1½-in. holes were drilled in the 8th diaphragm to admit high pressure to that stage in order to carry load swings of 2500-kw. above the rated load, without dropping from 25 to 24 ~. The turbine then carried the swings. On Feb. 14, 1918, at 4.55 p.m., a sudden load of about 10,000-kw. came on while the machine was carrying 32,000-kw. and rubbing and vibration took place first with a heavy shock and then with breaking up of the parts. The whole period was within six minutes, the breaking up being about 30 secs. The automatic valve shut off the steam. All wheels and diaphragms up to the 17th stage, inclusive, are intact. The blading of the 18th, 19th, and 20th wheels is gone, there is one small piece out of the rim of the 20th wheel, presumably struck by a fragment. The design of the wheels is proved to be correct; there had been some apprehension about the 20th wheel and the designer's values had been specially checked by the Massachusetts Institute of Technology. The tensile strength is 130,000 lbs., elastic limit 78,000 lbs. per sq. in., diam. 12 ft. 1 in., and tip speed 950 ft. per sec. at 1500 revs. per min. When the new blading is fitted the great web supporting the bearings at the generator end will be of steel. The universal

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use of cast iron in making diaphragms is due to difficulties in the use of steel; one large ring and one large disc connected by nozzles or stationary buckets have to be cast. The use of steel is discussed. W. N. Y. K.

302. *High Pressure and Superheat for Steam Plants.* **E. Berg.** (Gen. El. Rev. 21. pp. 216–221, March, 1918. Presented at meeting of the Am. I. E. E., Schenectady, Jan., 1918.)—Explains the efficiency of a steam turbine as the ratio between the actual measured water-rate and the theoretical water-rate. The theoretical water-rates per kw.-hour at steam pressures from 150 to 250 lbs. gauge, and superheat from 0 to 200 deg. F. are tabulated. A formula for calculating the available energy in steam is given and an example is worked out. The gain due to high pressure is discussed. Tables show the available energy, its percentage increase, and the net gain in fuel for pressures from 200 to 1000 lbs. per sq. in. (abs.). A chart shows entropy-temperature curves. A sectional diagram of a 10-stage turbine shows the steam conditions at all stages. With 200 lbs. gauge pressure, 150 deg. superheat and 28·5-in. vacuum the efficiency is about 31·25 %. At 500 lbs. pressure and 288 deg. F. superheat the efficiency increases to 36·3 %, and at 800 lbs. pressure, 800° F. temperature, the efficiency is 38·75 %. At this last figure the equivalent fuel-oil consumption is 0·62 lb. per kw.-hour. For Diesel engines 0·55 lb. per kw.-hour is claimed, but the fuel costs are 50 % more. W. N. Y. K.

303. *Elastic Coupling of Prime Movers and Generators.* **O. Ohnesorge.** (Zeits. Vereines Deutsch. Ing. 62. pp. 77–78, Feb. 16, 1918.)—In a previous article [Abs. 703 (1916)] the author pointed out that the oscillations of generating plant are set up not only by irregular driving moment, but also by the presence of elasticity in the coupling between the prime mover and generator. On this account the provision of elastic couplings to hinder any hunting of the units may exaggerate the trouble that is to be counteracted unless certain specific conditions are fulfilled. It is necessary that the coupling employed should have a definite elastic constant, but the proposal that all such couplings that are obtainable on the market should be classified according to this feature is hardly practicable. As a matter of fact, the couplings that are obtainable have in general far too low a power of storing energy. The present article describes with illustrations the main features of the design of an elastic coupling with adjustable elasticity and having the property of causing the forces to act on a comparatively large volume of the working fluid that provides the elasticity, a defect of most commercial couplings lying in the fact that there is not room within the coupling to bring sufficient working fluid into action. In the design shown the coupling consists of two parts connected together by pistons working in cylinders containing oil kept under pressure by connection with an air receiver to which the cylinders are joined by an oil-filled pipe passing through a hollow shaft. The elastic forces are able to be adjusted, even during running, by means of the pressure and volume of the air-receiver. A. J. M.

304. *Boilers with Air-heaters.* (Engineering, 105. pp. 228 and 230, March 1, 1918.)—In the new station of the Northampton Electric Light and Power Co. the circulating and air pumps are to be driven by steam and the exhaust used to heat the feedwater to about 200° F. In order to use the heat in the gases leaving the boiler, heaters are installed to heat the air supply to the furnaces. Each of the two boilers is equipped with a heater of 86 elements of inverted U-form, and the gases of combustion pass between the

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elements. The warm air from the generators passes through the interior of the heater elements to the fan suction. From the fan the air is driven into the air duct under the grate. Each element is 10 ft. long × 4 ft. 5 in. deep, and the heater chamber is 9 ft. 3 in. wide; with dust hopper below, and cleaning doors above. The fans are driven by electric motors. There are three motors to two fans in order to avoid stoppage. Extracts from the specification show the extent and requirements of the plant.

Each boiler has 5846 sq. ft. heating surface and evaporates 21,000 lbs. per hour from feed-water at 100° F. at 200 lbs. per sq. in. Steam is superheated to 650° F. Grate area is 72 sq. ft. Each fan will deliver 22,500 cub. ft. hot air per min. against 3-in. water pressure, absorbing 20 b.h.p. Guaranteed efficiencies for combined boilers, superheaters, air-heaters, and stokers are: Full and three-quarter load, 80 %; 25 % overload, 78 %. Heating surface for each air-heater, 2668 sq. ft. Temperature of gases leaving air-heater, 400° F., and of air entering stoker, 280° F. Plan, elevation, and sectional views of the apparatus are given. W. N. Y. K.

305. *Boiler-house Operation with Reference to Various Fuels.* **Knust.** (Elekt. Werk. 6. 1916. Elektrot. u. Maschinenbau, 35. p. 47, Jan. 28, 1917. Abstract.)—It is economically preferable to distil hard coal rather than use it directly under boilers. All bituminous coals should be subjected to distillation. The author investigates the possibilities of substitutional fuels for boilers. For any given fuel there is direct dependance between the temperature of combustion, the quantity of air for combustion, the CO_2 content, and the temperature of the flue gases. The higher the CO_2 content and the lower the temperature of flue gases the more favourable the utilisation of the fuel. The author gives formulæ for the initial temperature T, and by comparing this with the measured value, t, the loss of fuel may be determined at once. If $T = 2000°$ C. and $t = 800°$ C., the gross efficiency of the firing is $(2000-800)/2000$, *i.e.* 85%; for $T = 2000°$ and $t = 200°$, $\eta = 90$ %.

The author gives a table comparing gross efficiency, initial temperature, air surplus, and air and flue-gas quantities for a specified coal and various CO_2 contents. Formulæ are given for the air theoretically required for combustion and for the volume of flue gases developed. A daily consumption of 10,000 kg. of coal when the CO_2 content is 12 % and the flue-gas temperature 200° C. corresponds to 33,400 kg. per diem when the CO_2 content is 4 % and the flue-gas temperature 400° C.; the great saving under the former conditions is obvious. A table is given showing for the principal fuels, the calorific value, evaporation factor, max. CO_2 content, initial temperatures, and overall efficiencies. Charts for four of the most important of these fuels show the efficiency as a function of the CO_2 content and the flue-gas temperature.

A mixture of 1 part of coke to 2 of hard coal yields no difficulties in working; and a mixture of 1 coke to 3 of brown-coal briquettes is also satisfactory. Thoroughly good mixing is the principal requirement. If coke be used alone, the grate, air supply, and stoking arrangements must all be modified. Using brown-coal briquettes instead of hard coal adds about 60 % to the grate and 14 % to the smokestack duty. A formula is given expressing the cash value of substitutional fuels in terms of heating value. R. E. N.

306. *Gas-firing of Boilers.* **T. M. Hunter.** (Inst. El. Eng., J. 56. pp. 57–74; Disc., 74–91, Jan., 1918. Abstracts in Electrician, 80. pp. 270–271, Nov. 23.

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and pp. 307–308; Disc., 308–309, Nov. 30, 1917. El. Rev. 81. pp. 509–510, Nov. 30; 549–551; Disc., 551–552, Dec. 7, and pp. 573–574, Dec. 14, 1917. Engineering, 104. pp. 613–616, Dec. 7, 1917.)—Gives a number of tables of heat losses, calorific values, composition, etc., of coke-oven, blast-furnace, and producer gases in order to enable results obtained from gas-fired boilers to be tested. The main reason for blast-furnace gas not being used with greater success is that it carries large quantities of dust, resulting in decrease of evaporation and frequent cleaning of the plant. Regenerative coke-oven gas has higher calorific value than blast-furnace gas, but the efficiency is still low. Calorific values of the common constituents of gas are tabulated:—

	Gross.		Nett.	
	B.Th.U. per cub. ft.	Kg. cals. per cub. m.	B.Th.U. per cub. ft.	Kg. cals. per cub. m.
Carbon monoxide	344	3062	344	3062
Hydrogen	342	3042	293·5	2613
Methane	1063	9460	966	8598
Ethylene	1724	15300	1627	14480
Hydrogen sulphide	659	5860	619	5513

Estimates are made as to the steam-raising values of coke-oven, blast-furnace, and producer gas. The suitability of gas, according to its constituents, for boiler-firing is considered and analyses of several gases are given:—

	Coke-oven.	Blast-furnace Coke Gas.	Moore Producer.	Mond Producer.
	%	%	%	%
CO_2	—	12	12·7	16
CO	8·1	29	15·5	8
H	49·1	1·5	20·2	23·4
CH_4	32·6	0·7	2·2	3·2
C_2H_4	3·1	—	—	—
N	6·6	56·8	49·4	49·4
O	0·5	—	0·2	—
	therms	therms	therms	therms
Calorific value (cold)	540	112	182	130
Loss by latent heat in vapour of combustion	58½	1½	12½	17

It is important that gas should be dry when burned, as water-vapour reduces the flame temperature and carries a large quantity of sensible heat to waste. A comparative example is worked out for gases containing in one case 12 to 15 gm. per cub. m. of water-vapour, and in the other case 362 gm. per cub. m. The flame temperature is reduced from 1320° C. in the first case to 1090° C. in the second, and the boiler efficiencies are 75·3 % and 71·3 %. The cost of cleaning gas is about 2d. per 35,000 cub. ft. by either wet or dry process. Heat transference and improvements in effecting it are discussed, *e.g.* by fixing projecting pieces or rings of angle iron to increase the surface. The adaptation of various types of boilers to gas firing, draught, boiler settings, gas measurement, and boiler control are dealt with.

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In the *discussion*, **C. P. Sparks** said that the manner of obtaining the gas was of fundamental importance. One method was to take it as a by-product from coke-ovens, another method was to obtain as much gas as possible from the coal and obtain a poorer quality of coke as a by-product. A third method was to obtain various products of low-temperature distillation for producing a new type of fuel for household purposes, with gas, tar, and oils as by-products. The future of gas for large electric supply undertakings is closely connected with the process of complete gasification of coal, saving part of the volatiles as by-products. **W. B. Woodhouse** thought the estimated values of surplus heat from coke-ovens and blast-furnaces too high. **H. W. Kolle** said that the chief difficulties in the way of using blast-furnace gas were the trouble involved in storing the gas and the variation of pressure in the gas main. **L. B. Atkinson** remarked that it was claimed that nitrates could be made from the atmosphere at £2 or £3 a ton; hence it would be a mistake to rely on selling sulphate of ammonia, to use for the same purposes, at £9 a ton or higher. W. N. Y. K.

307. *Failure of Boiler-plates in Service and Investigations of Stresses in Riveted Joints.* **E. B. Wolff.** (Iron and Steel Inst., J. 96. pp. 137–158; Disc., 159–179, 1917. Engineering, 104. pp. 826–830, Sept. 28, 1917. Power, 47. pp. 166–167, Jan. 29, 1918.)—The results are given of a research undertaken with a view of finding the causes of the cracking of boiler-plates over the riveted seams. The boilers were of the ordinary marine type with three flues. The shell plates and the rivets were generally approximately 32 mm. thick, some of acid and some of basic steel, with an ultimate tensile strength of 42–48 kg./mm.^{2} and an elongation of 23 to 20 %. The phosphorus and sulphur were under 0·05 %. The types of cracks are described and illustrated and the following conclusions are drawn from the work:—The cracks are in most cases invisible at the beginning and can only be observed after etching the plates. They are found either on the inner surfaces of the rivet-holes or on the surfaces of the plates where these are pressed together. They are found in lap joints as well as in butt strap joints, in shell and front plates as well as in fire-box plates. The real stresses in different places of the riveted joints have been measured by a special Okhuizen extensometer, and it has been proved that the supposition that these cracks have been caused by "fatigue" of the material is probably correct. C. O. B.

308. *Investigation of a Fractured Header.* **R. Baumann.** (Zeits. Vereines Deutsch. Ing. 61. pp. 953–958, Dec. 1, and pp. 973–978, Dec. 8, 1917.)—An investigation into the cause of failure of the header of a water-tube boiler which suffered a disastrous explosion in June, 1912, is described by the author. The boiler was of the small tube type operated at a pressure of 190–210 lbs. per sq. in. After the explosion the surrounding plate, which had been welded so as to connect the front and back of the header, was found to have been completely torn out, and was submitted to mechanical and metallographic examination. Bending tests indicated that in 11 out of 12 cases the mechanical properties of the material were satisfactory; in several cases fracture occurred outside of the weld. Direct visual examination revealed the fact that fracture had not followed the line of the weld for the whole of its length. Microscopic examination showed that the weld did not contain an undue proportion of slag, and that burning could only be observed to any marked degree in two places. The external appearance of the weld was against it, but the author concludes that although the weld was not a

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specially good one, it could not be considered as a faulty one if the size and shape of the welded object were taken into consideration. F. C. A. H. L.

309. *A Fifty-thousand Square Foot Condenser.* (Power, 47. pp. 282–285, Feb. 26, 1918.)—The American Gas and Electric Co. has installed at the Windsor power plant two 50,000 sq. ft. Leblanc surface condensers, in the bottom of a pit 74 ft. deep, to serve two 30,000-kw. turbines; when the plant is completed there will be six. Each condenser is of the straight downflow type with the tubes spaced to distribute the steam. The tubes are of Muntz metal, 18 B.W.G. and 18 ft. long. The body is 18 ft. internal diam. × 25 ft. long. About 2400 sq. ft. of the upper portion of the tube area is used as a primary feed-heater through which the condensate is pumped, its temperature being thereby brought nearly up to that of the incoming steam. The main exhaust pipe is 40 ft. long × 18 ft. diam. A special novel mercury expansion joint allows for changes in length. The upper part of the joint is made so that an ordinary soft packing may be used in case the mercury should fail. The motor-driven horizontal circulating pump has a capacity of 50,000 galls. per min. Make-up water is taken from the circulating water discharge. The condenser is supported 15 ft. above the bottom of the pit on steel cross members above the pumps. The screens for the water are described. The expansion joint and general elevation of the plant are illustrated. W. N. Y. K.

310. *Use of Culm and other Waste Materials from Coal-washing Plants for other Purposes.* **J. B. C. Kershaw.** (Met. and Chem. Eng. 18. pp. 25–28, Jan. 1, 1918.)

311. *Modern Methods for the Storage of Coal.* **G. F. Zimmer.** (Engineering, 105. pp. 80–82, Jan. 11, and pp. 57–60, Jan. 18, 1918.)

312. *Steam- and Electrically-driven Station Auxiliaries.* **V. Pickles.** (Electrician, 80. p. 241, Nov. 16, 1917. Abstract of paper read before the S. African I. E. E.)—The two chief factors in deciding whether station auxiliaries shall be driven by steam or electricity are reliability and running costs. For condenser auxiliaries a case is assumed, thus: Power required, 150 kw. With electric drive, motor efficiency 85 %, transformer 97 %: the demand on the busbars is 188 kw. With steam turbine, say 20 % less efficient than the main turbine taking 15 lbs. steam per kw.-hour, exhausting into a convenient place in the main turbine: the steam used would generate 180 kw. in the main set. This shows the efficiencies of the two systems as about equal. The steam turbine has the advantage in reliability. With feed pumps greater reliability is obtained with steam-driven pumps.
W. N. Y. K.

GAS, OIL AND WATER ENGINES.

313. *The Relation of the By-product Gas-producer to Power Generation.* **H. R. Trenkler.** (Zeits. Vereines Deutsch. Ing. 62. pp. 85–91, Feb. 23, 1918.)—The author analyses the results that can be obtained with four typical fuels (1) by direct burning under steam boilers, (2) by gasification and recovery of the by-products with use of the gas for steam generation, and (3) by gasification and recovery of the by-products with use of the gas in gas engines. The

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figures obtained for the cost of the kw.-hr. in each case are summarised in the following table, the values being expressed in marks.

Type of Fuel.	Cost in Marks per Kw.-hr.		
	Burned, and Steam used in Steam Turbines.	Gasified, and Steam used in Steam Turbines.	Gasified, and Gas used in Gas Engines.
	I	II	III
1. *Lump coal* testing 7000 kg. cals. with 1·25 % N and 6·5 % tar, at 13·0 M. per ton.....	1·603	1·581	1·462
2. *Low-grade fuel*, testing 6000 kg. cals. with 1·00 % N and 5·5 % tar, at 5·0 M. per ton	1·086	0·764	0·992
3. *Lignite briquettes*, testing 4800 kg. cals. with 0·60 % N and 9 % tar, at 8·50 M. per ton.....	1·557	1·499	1·415
4. *Raw lignite*, testing 2800 kg. cals. with 0·80 % N. and 4·5 % tar, at 2·0 M. per ton	1·107	0·659	0·930

In conclusion, the author expresses the belief that the increased scarcity and cost of fuel after the war will cause gasification and recovery of by-products to be generally adopted, and that the gas engine and the gas turbine will in time oust the steam turbine from its present position in all power plants.

J. B. C. K.

314. *Agricultural Tractors.* **A. E. L. Chorlton.** (Engineering, 105. pp. 7–10, Jan. 4, 1918. Paper read before the Inst. of Automobile Eng.)—The problem of providing mechanical power to replace horse labour is affected by size of farm, class of land, nature of crop, road transportation, first cost, annual charges, etc. There is a marked deficiency in the amount of precise data available.

The services required from a power unit during the agricultural year are :—(*a*) Ploughing, rolling, dragging, drilling. (*b*) Reaping, binding, leading. (*c*) Threshing, pumping, pulping, chaff-cutting, grinding. (*d*) Transport to the station. With the help of such horses as are always available, these duties can be accomplished by a single tractor. They are not likely to occupy over 70 % of the working days per year. The various services may be classified thus :—(1) *Road work*—transport ; this governs minimum axle loading. (2) *Land work*—ploughing ; this governs max. axle loading. (3) *Farmstead* —threshing, etc. ; this governs minimum power required.

In road work, the basic factors are adhesion and resistance. Table I summarises typical resistance values for various surfaces. The standard figure for locomotive adhesion on rails is 0·25 (the actual value rising sometimes to 0·35). The author's tests with steel and rubber tyres on ordinary roads show max. adhesion of 0·56 for steel and 0·6 for rubber tyres. In designing a tractor for road transport the propulsive effort cannot be taken to exceed 0·45 × weight on driving axle for steel tyres. Rubber tyres are hardly justifiable in farm practice ; if they be used, 0·5 is a safe adhesive

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factor. For the present investigation, the resistance is assumed to be 60 lbs./ton. A 4½-ton threshing machine is probably the largest indivisible load which will have to be hauled. With a tractor weight of 2½ tons, the total propulsive effort required on a 1 : 10 gradient is 1988 lbs., corresponding to 4400 lbs. on the driving axle. This may be provided by utilising the reaction of the drive or else by artificial loading to supplement the tractor dead weight. The engine power required is 15·2 h.p. with 70 % gearing efficiency; and 13·2 h.p. with 80 % gearing efficiency.

TYPICAL VALUES FOR TRACTIVE RESISTANCE (LBS. PER TON).

Surface.	Lbs. per Ton.	Surface.	Lbs. per Ton.
Concrete, unsurfaced, smooth	27–30	Gravel, compact, good	75–82
Ditto, ⅜-in. surface asphaltic oil and screenings	49–52	Ditto, loose	263
Macadam, water bound, smooth	64	Earth road, ¾–2 in. of fine dust	92–99
Ditto, author's tests, good	58	Earth, stiff mud, firm bottom.....	218
Oil macadam, good new	78–81		
Topeka on concrete, smooth ...	68		
Topeka on plank, good but soft	88–98		

For work on the land, weight must not exceed a certain maximum (difficult to determine); extra tractive effort must be secured by wheel projections, spuds, etc. Sinking in the ground is seldom due to excessive weight but to slipping of the wheels which then scrape out soil from beneath. The lighter the axle loading, the greater the dependence on spuds, but the effectiveness of grip is reduced by the lighter weight and the rolling resistance per ton due to spuds is increased. Data to be ascertained are the proper relation of pressure on the land, pressure against it, and action of rim projection, strake, spud, or grouser. Pressures which have been usual on land are :—Man's boots, 8½; horse's hoofs, 20; cart tyres (2-ton load), 40 lbs./sq. in. A tractor with driving wheels 48 in. × 12 in., 3920 lbs. static axle load, and ¾-in. sinkage produces a pressure of 13·6 lbs./sq. in. Spud resistance is about 8 times plough resistance (lbs./sq. in. in each case). To take 2000 lbs. drawbar pull by one spud on each wheel, allowing a pressure of 50 lbs./sq. in., would need a spud 1·67 in. long on wheels 12 in. wide. This is for average land. On light soil the spud depth would have to be 4 times as great, say 6·7 in. Some form of actuated spade would be required to keep the rolling resistance within reasonable bounds but the mechanical complication of such a device is hardly justifiable. A caterpillar tractor is essential on very soft ground but is not necessary in most English agricultural conditions.

A discussion of test data given in the original brings out the following points :—(1) The desirability of providing enough engine power to permit the use of 4-share ploughs. (2) The advantage of using more efficient gearing on tractors. (3) The value of large flywheel effect to equalise load.

Allowing a margin of safety, fundamental values for the multi-purpose tractor may be taken to be :—

For—	Power Required.	Load on Driving Axle.
Road work.....	18–20 h.p.	4400 lbs.
Land work.....	23–25	4400 lbs.
Farmstead	20–25	Stationary

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In order to allow for unskilled attendance, the engine should possess a considerable reserve of power; low speed, large cylinder capacity (per h.p.), strength and simplicity of parts are important factors. The engine should operate on paraffin and develop its output without water injection. A high-compression engine might save 30 % of the paraffin consumption and its automatic ignition is an important simplification. Often more and sometimes less than 3 galls. of paraffin are used per acre. The consumption is probably more than 0·96 pint per b.h.p.-hr. as a rule; but it should be possible to realise 0·85 pint per b.h.p.-hr., or even 0·6 pint or less with a high-compression engine. A motor-car factory would naturally prefer to build tractors with 4-cylinder vertical engines. Otherwise the horizontal type may be preferred. High-speed vertical engines yield a light tractor but a speed not exceeding 500 r.p.m. is more suitable for farm conditions. It is important to provide for good vaporisation under all conditions and to ensure that surplus paraffin cannot drain into the crank chamber. Water injection is not recommended. Full power should be obtained with a mean pressure not exceeding 50 lbs. per sq. in. In the horizontal engine recommended, the flywheel effect provides 50 % power increase for 30 secs.; in a light tractor with high-speed engine there is less storage and the engine sustains greater shocks. Tank cooling is simpler and safer where dirty water may be used; radiator cooling needs much less make-up water.

Weight may be saved by incorporating the frame in the general design of a multi-purpose machine. With a 900-rev. engine, 64 : 1 gearing is required for 2 miles/hr.; with an engine speed of 475 r.p.m. the reduction is only 34 : 1. In the former case motor-car practice, with bevel or worm gears, may be followed. With a cross-set low-speed engine neither bevel nor worm gear is needed; the gearing should be enclosed and run in an oil bath. Double-pivot steering is preferable for small tractor work. The wheel arrangement recommended is 2-track, 4-wheel with 3 ft. × 5 in. front, and 4 ft. × 1 ft. rear wheels. Both axles should be sprung. R. E. N.

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PROPERTIES OF ENGINEERING MATERIALS.

315. *The Use and Abuse of Steel.* **R. K. Bagnall-Wild and E. W. Birch.** (Inst. of Automobile Eng., Proc. 11. pp. 307–368, 1916–17. Engineer, 123. pp. 384–386, April 27, and pp. 430–433, May 11, 1917. Mech. Eng. 39. pp. 388–390, May 25, and pp. 400–402, June 1, 1917.)—The authors point out that steels of widely different compositions can be made to give the same mechanical tests by different heat-treatments, and, further, that widely different mechanical properties can be bestowed on the same steel by the same means. Resistance to abrasive wear is an important factor in the choice of steel by composition. Experience has shown that a relatively high-nickel steel does not resist abrasion so well as a low-nickel steel containing a small amount of chromium. High-chromium steels are objectionable on account of their tendency towards cracking. Longitudinal "hair cracks" have been shown to form starting-points for circumferential fractures. The authors consider that in addition to the usual clauses contained in steel specifications there should be a clause dealing with the size of ingot for the particular purpose for which the specification was drawn up. The direction of "flow lines" in stampings and forgings is a very important factor. Closer co-ordination between designer, steel-maker, stamper, and the manufacturer of finished machined components is desirable. The paper contains a large number of illustrations of steels which are defective from various causes.

F. C. A. H. L.

316. *Structures in Steel Fusion Welds.* **S. W. Miller.** (Am. Inst. Mining Eng., Bull. No. 134. pp. 891–408, Feb., 1918.)—In fusion welding by electricity or oxy-acetylene there is an agitation of the heated metal, which in the case of electric welding is quite violent, resulting in more or less oxidation. The author has never found a fusion weld free from considerable amounts of oxide. The weld also contains large amounts of gases such as nitrogen, and probably hydrogen, in the oxy-acetylene process. The addition of V, Mn, or Ti, or combinations of these, to the welding rod is an improvement, but the difficulty of welding is increased, especially with manganese. The agitation of the melted metal, and the melting of the original material, cause a mixture of the high- and low-carbon materials, especially near the edge of the weld. A certain amount of carbon is also burned out during the melting, so that the carbon content of the metal is altered towards the centre of the weld. Further, there is great variation in the heating and cooling rates, and in the composition of the welding rods used commercially, so that great differences in structures of welds may be expected. The author has investigated these differences by means of a large number of photomicrographs which are reproduced in the original paper. All the electric fusion welds, and some of the oxy-acetylene welds, show the presence of lines parallel to the sides and diagonals of a square to the middles of the opposite sides. These lines have been variously attributed to oxide, magnetic oxide, or cracks, but the author considers them to be very minute plates of cementite rejected along certain crystallographic planes. The similarity of these lines to Neumann lines and lines due to nitrogen and corrosion points to an intimate relationship between them all, and the author suggests that Neumann lines are lines of incipient fracture; that the rejection of free cementite to the planes it occupies, and the location of the lines caused by

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nitrogen and corrosion, are because of the inherent weakness of these planes, which weakness would seem to be manifested by the appearance of slip bands in the same directions. R. J. W.-J

317. *Boro-Silicon Glass for Insulators.* (U.S. Pat. 1,288,486. El. World, 70. p. 951, Nov. 17, 1917. Abstract.)—An improvement on his boro-silicon glass, useful for high-tension insulators, is described by F. M. Locke in his specification. The primary object is to produce an electrical insulator particularly adapted for conductors of high potential without the fusing temperature of the mass being raised to such an extent as to preclude economical production.

The following percentages of the mix are suggested :—

	A	B	C		A	B	C
SiO_2	71	75	70	Al_2O_3	—	5	2
B_2O_3	28	15	13	Na_2O	—	4	—
Li_2O	1	1	9	Sb_2O_3	—	—	6

Among other things it has been discovered that the addition of a nitrate—as, for instance, potassium nitrate or sodium nitrate—to the mix in manufacturing the insulator results in the production of a substantially pure-white transparent glass at lower fusion temperature. L. H. W.

318. *Making Wagon Wheels in 5-Roll Mills.* **L. Geuze.** (Rev. de Mét. 14. pp. 717–729, Nov.-Dec., 1917.)—Two shafts forming a V (in plan) are driven through bevel gearing from a horizontal shaft running across the back of the mill. Bevelled rolls at the apex of the "V" form the web of the wheel. The other three rolls are not driven positively : one forms the rim diam., the other pair form the rim thickness. It is difficult to make accurately and simultaneously the three control adjustments needed. If the wheel be made too large in diam. it must be reheated and passed through the rolls again. Since the web rolls are the only ones they must be used, and it is probable that the web will be made too thin during the second rolling. In successive sections of the paper the author deals with the calculation of dimensions for the ingot and rough forged or rough pressed blank to be delivered to the mill to produce a wheel of stated dimensions ; he deals also with the details of manipulation of the mill. The study covers : (1) The various phases of forging the ingot to produce a blank ready for rolling, and the form and dimensions of tools needed for this forging with a 1500-ton press. (2) The serious inconveniences in operation involved by this (German) type of mill.

If the wheel exceeds 800 mm. in diam. the blank is passed through roughing and finishing dies. Smaller blanks are made by finishing dies alone, and it is economical to use a press of such power that this can be done in any case. Owing to the inadequate power of the press used in the plant described, the upper die is made rectangular and of such width as to cover about 0·4 of the wheel diam. The lower die is circular and it and the blank are driven electrically through a clutch which slips when the press lowers the top die. The blank is turned through part of a revolution between each stroke of the press. After leaving the mill the wheel is trued and the web waved (if required) by a die press of 800 to 1000 tons.

It is concluded : (1) That a 1500-ton press is inadequate for the economical forging of blanks for wheels exceeding 800 mm. diam. (2) That the mill described does not meet practical, industrial exigencies, because rolling is left to the care of workmen without it being possible to guard against

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mistakes which they may make in manipulating three sets of rolls during the rolling period which occupies only 40 to 45 secs. (3) That to obtain good results at low cost we must use a press powerful enough to forge the blank without the intervention of roughing matrices, and a rolling mill still more easy to manage and of altogether more practical construction. R. E. N.

319. *On Water-hammer in a Pressure Pipe having Walls of Variable Width for the Case of Progressive Closure.* **de Sparre.** (Comptes Rendus, 166. pp. 144–148, Jan. 28. 1918.)—In previous communications the author has dealt with a pipe formed of three sections, the speed of propagation varying only from one section to the next. He now shows mathematically that if a rate of closure be assumed such that the total closure cannot take place in less time than that for a complete oscillation, then the max. water-hammer will be the same as that obtained if there be assumed a constant speed of propagation equal to the average value. H. H. Ho.

320. *Properties of the Calcium Silicates and Calcium Aluminate occurring in Normal Portland Cement.* **P. H. Bates** and **A. A. Klein.** (Bureau of Standards, Techn. Paper, No. 78. [88 pp.], Washington, 1917.)—This monograph contains a considerable amount of tabulated data regarding the samples tested, and is illustrated with numerous photographs of the sections, briquettes, fractures, etc. It is not possible here to do more than reproduce a few of the more important conclusions from the author's summary.

(1) At early periods the constituents of Portland cement of normal composition and manufacture, in the order of their strength-conferring properties, are: Tricalcium silicate, tricalcium aluminate, and dicalcium silicate. (2) At periods beyond 28 days the dicalcium silicate gains sufficient strength to place it almost on an equality with the tricalcium silicate. (3) Tricalcium aluminate containing 10 % plaster gains practically no strength after the first period at which it was tested; that is, 24 hours. (4) Tricalcium silicate of the purity used in this investigation (90 % 3 $CaO . SiO_2$ in one case and 90 % in the other) has all the important properties of Portland cement, especially those of the "rate of setting" and strength developed. (5) Dicalcium silicate, such as used in this investigation, sets too slowly and attains strength too slowly to be of any commercial value when used alone. (6) Tricalcium aluminate alone, as used in this investigation, sets too rapidly and attains too little strength to be of any commercial value as a hydraulic cementing material. (14) The composition of Portland cement should, it would seem, be along lines which would not produce a great preponderance of either silicate. The ideal cement should possibly have an excess of the dicalcium silicate, which would give a not too dense hydrated material, gaining strength at later periods. A lesser amount of the tricalcium silicate would furnish the desired early strength and also overcome the excessive porosity of the dicalcium silicate. (15) It is possible to make a cement that will have the properties of Portland cement by grinding together the constituents previously separately burned in approximately the amounts in which they exist in Portland cement. L. H. W.

321. *The By-product Coke Oven and its Products.* **W. H. Blauvelt.** (Am. Inst. Mining Eng., Bull. No. 135. pp. 597–614, March, 1918.)

322. *Principles and Practice of Sampling Metallic Metallurgical Materials.* **E. Keller.** (Bureau of Mines, Bull. 122. [96 pp.], Washington, 1916.)

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323. *Molybdenum; its Ores and their Concentration.* **F. W. Horton.** (Bureau of Mines, Bull. 111. [125 pp.], Washington, 1916.)—A complete monograph on the subject, with lengthy bibliography. L. H. W.

324. *Deteriorating Action of Salt and Brine on Reinforced Concrete.* **H. J. M. Creighton.** (Frank. Inst., J. 184. pp. 689–704, Nov., 1917.)—The following conclusions are drawn by the author from his investigations of the action of salt and brine on reinforced concrete:—(1) All concrete which is not waterproofed in some way is more or less porous to water and brine. (2) Brine readily softens the surface of concrete and, therefore more easily penetrates to the reinforcements, on which it exerts a disintegrating action that, owing to the attendant expansion, gradually weakens the concrete, causing it to crack and split, and in some cases to fall away from the reinforcements. (3) The more porous the concrete, the more rapid the disintegration of the reinforcements through the action of brine. (4) Reinforced concrete floors which come in contact with brine will gradually develop leaks. These will be followed by incrustations of discoloured salt on the under side, where, later, iron-stained, hair cracks will develop running parallel to the reinforcements. As the deterioration progresses, the cracks will widen, and, owing to the great expansive force of the accumulating iron oxide, the concrete will be gradually pushed from the corroded reinforcements and ultimately fall. L. H. W.

325. *Power required by Cold Rolling Mills.* **C. E. Davies.** (Engineer, 125. pp. 221–222, March 15, 1918.)—The maximum reduction in thickness, or "draught," depends not only on the capacity of the rolls, which is the limiting condition in hot rolling, but also on the max. safe bearing pressure which should not exceed 2500 lbs. per sq. in. The power required by the mills is given by: h.p. $= D^3N/K$; where D is the diam. of the rolls in inches, N the revs. per min., and K a constant. This formula, originally derived empirically, is shown to have a theoretical basis. Values for K derived theoretically for net h.p. are rather lower than those derived from practice for gross h.p., and, therefore, if taken to represent gross h.p. give for design purposes a margin of power on the right side. A numerical table of reductions, h.p., and revolutions is given in the paper.

Metal.	Reductions in Thickness.	K.
Soft copper	0·0154 D.	310
Hard copper and brass	0·0087 D.	385
Soft steel	0·0056 D.	445
Medium steel and nickel silver ...	0·0038 D.	500
Hard steel and hard nickel silver...	0·0028 D.	550

The efficiency depends on the rolling angle and the friction, and can only be increased by reducing friction. W. A. R.

326. *The Whirling of Shafts.* **H. A. Webb.** (Engineering, 104. pp. 455–456, Nov. 2; 483–485, Nov. 9, and pp. 513–515, Nov. 16, 1917.)—The calculation is of interest in connection with the shafts of large turbo-alternators and other turbo-machinery. The author develops a graphical method based upon a hitherto unpublished approximate method due to W. H. Barling. He works out the rigorous results for four particular kinds of

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shafts and also gives an example of the graphical method. The approximate method is applicable to practical shafts of a very wide range. L. H. W.

327. *Maximum Power and Speed of Belt Pulleys and Gear Wheels.* **W. Kummer.** (Schweiz. Bauzeit. 30. No. 5, 1917. Elektrot. u. Maschinenbau, 35. p. 629, Dec. 30, 1917.)—The author investigates max. practicable values for power and speed in belt pulleys and gear wheels, basing his results upon the max. peripheral force, P kg., transmitted. *In belt drives* P depends upon the tensile strength of the belt referred to the max. peripheral force which can be transmitted. Using quadruple Ideal leather, total thickness 16 mm., with large pulleys, favourable transmission ratio, and high belt speed, a force of $p = 55$–56 kg. per cm. of belt width can be utilised continuously. If the belt width $= b$ cm., $P = pb$. Let $q = b/D$, where $D =$ diam. in cm. of the smaller pulley, then the moment M in kg.-cm. on this pulley $= D^2qp/2$. Introducing the revs. per sec. n, and an experimental factor K (in cm./sec.^{2}), we have $D^2 = K^2/n^4$, hence $K^2/n^4 = 2M/qp$. Since the horse-power $L = 2\pi nM/7500$, we have $Ln^3 = \pi qpK^2/7500$. Taking the highest values which can be realised in practice without going to extremes, we have p 50≈kg./cm.; q≈0·75; and K ≈ 8000 cm./sec.^{2} which yields $Ln^3 = 1{,}000{,}000$ approximately. This equation is plotted in the original. *In gear drives*, the force P operative at the periphery is $P = kb^2/\psi$; where $b =$ width of gear wheel in cm., $k =$ experimentally determined coefficient of bending strength of the teeth in kg./cm.^{2}, and $\psi =$ ratio of wheel breadth to tooth pitch. By introducing the ratio $q = b/D$, the turning moment M in kg.-cm., is $M = D^2q^2k/2\psi$. Again, by introducing the revs. per. sec. (n), the constant K, and the horse-power L, we obtain the equation $Ln^5 = (\pi q^2kK^2)/(7500\ \psi)$, as expressing the relation between max. power and speed for the smaller gear wheel. This expression appears also in the general form $Ln^5 =$ constant, as the general relation between nominal power and speed in standard electrical machinery. According to American practice in ship driving, suitable values for the constant in the above equation are: $(k/\psi) \sim 60/30 \sim$ 2 kg./cm.^{2}; $q \sim 1{\cdot}4{\cdot}0$; K ∼ 53,000 cm./sec.^{2} Then $Ln^5 \sim 2 \times 10^{12}$.

The curves plotted between L and n for belts and gears from the above formulæ represent the virtual limits of present-day practice (say up to 5000 h.p. for belts and 12,500 h.p. for gears), assuming the same general construction in each type of drive from various horse-powers. Though these curves will change as practice advances, the general formulæ $Ln^3 =$ constant and $Ln^5 =$ constant will hold good for belts and gears respectively, so long as the appropriate factors are used in determining the constant term.

R. E. N.

328. *Viscosity and Chemical Constitution of Lubricating Oils.* **A. E. Dunstan** and **F. B. Thole.** (Engineering, 105. p. 433; Disc., 433–434, April 19, 1918. Correction, *ibid.* p. 500, May 3, 1918. Paper read before the Inst. of Petroleum Technologists, April 16, 1918.)—The high-boiling fractions of petroleum are very complex mixtures of small percentages of paraffin hydrocarbons; of large percentages of unsaturated hydrocarbons ranging from C_nH_{2n} to C_nH_{2n-6} (probably naphthenic or polynuclear); a small amount of aromatic compounds; some sulphur, and some oxygen compounds; these last being probably responsible for the gumming properties. Some of these compounds have been isolated; the unsaturated compounds can be extracted by means of strong sulphuric acid; a further differentiation is effected by means of formaldehyde (Nastyukov) or methylal:

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(Heer), when the formolites are precipitated, and in other ways. In no case, however, has the constitution of a constituent of lubricating oils been determined, though the synthetic researches of Engler and of Krämer and Spilke are promising. The authors determine the viscosity of many oils in absolute measure (by an Ostwald apparatus provided with a Lowry toluene regulator), and the temperature coefficient of viscosity; the average molecular weights (by observing the freezing-point depression in pure naphthalene); the ratio of carbon to hydrogen (by elementary analysis); and the iodine and bromine values. The viscosity is not a measure of the oiliness or body of an oil; this latter property depends upon unknown factors: the two properties often go together, but aqueous solutions of sucrose and of glycerol, *e.g.* have high viscosities without lubricating values. The authors propose to determine, with the aid of a capillary glass tube, both viscosity and surface tension, the latter from the weights of the following drops. Viscosity is a constitutive property, depending upon relative molecular surface and molecular volume. The viscosity is in general raised by high molecular weight, unsaturation (latent valency), alternation of double and single linkings of carbon atoms (the conjugated double bonds of Thiele), and unsymmetrical molecular structure. When the unsaturated compounds are extracted, the remaining oil has a lower density and viscosity, but a higher molecular weight; the viscosity curves tend to approach one another at higher temperatures, and the logarithms of the viscosity-temperature curves are nearly linear over a wide range of temperature (not at the ends), and intersect at high temperature. A lubricating oil should contain a proportion of unsaturated hydrocarbons, as large as is compatible with not too much susceptibility to oxidation, polymerisation, gumming, and reactivity. Dilution with saturated hydrocarbons does interfere with the chemical activity, but the diluent, though not inessential, probably in no way assists lubrication. Acid treatment of lubricating oils should be reduced to a minimum, since it removes not only harmful resins, but also constituents essential for their viscosity and body. The physical condition of a good lubricant is probably colloidal (Schneider and Just), and colloidal investigation is most desirable. If the oils be iso-colloids, *i.e.* polyphase systems in which the disperse component is of the same chemical nature as the dispersion medium (just as water is a mixture of hydrol (H_2O) and trihydrol ($(H_2O)_3$), while the oiliness would be the effect of the degree of dispersion, and the hysteresis phenomena of heavy oils would be intelligible. With the aid of a parabolic substage condenser the authors obtained a Tyndall cone effect in oil, suggesting very small colloidal aggregates. There is also a characteristic fluorescence distinctive of types of oils, green in Persian oil, brilliant blue in Burmah oil. The authors have so far chiefly studied mineral oils. In the *discussion*, **Anfilogoff** mentioned that too much attention was paid to the pale colour of lubricants, which was secured by the undesirable action of strong sulphuric acid.

H. B.

329. *Multi-stage Compression Plant of Central Cold Storage Co.* (Power, 47. pp. 74–78, Jan. 15, 1918.)—Gives an illustrated description of a two-unit ammonia refrigerating plant of 500 tons in capacity in Chicago. The system devised by D. J. Davis has, as its main features, multi-stage compressors and cooling of the vapour between stages to a temperature corresponding to the saturation-point for the intermediate pressure. The high-pressure cylinder is thus enabled to be smaller and the temperature of the discharge to the condenser is kept down. The structure and arrangement of the building is

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described. There are over 9 acres of floor area and 3,500,000 cub. ft. of storage. The refrigerating plant is in the sub-basement. There are two double-acting cross-compound compressors; the first stage cylinder is 28-in. diam. and the second stage cylinder 20½-in. diam., by 48-in. stroke. The drive is at 60 r.p.m. direct from a cross-compound engine 20- and 42-in. by 48-in. The space for each unit is 828 sq. ft. Calcium-chloride brine, density 1·260, is used; its temperature is reduced to −22° F. in four horizontal shell-type coolers. Ammonia vapour from the brine coolers is drawn to the low-pressure cylinder of the compressor at a pressure of 1 to 4 lbs., thence it is passed to an intermediate drum at a pressure of 25 to 30 lbs. The vapour heated by this compression is cooled by the liquid ammonia, at 17·5° F., coming from a cooler placed between the condensers and brine coolers. The ammonia leaves the condensers at a temperature of 90° F. The 72·5 deg. drop is effected with a suction pressure of 25 to 30 lbs. instead of 1 to 4 lbs. for the low-pressure cylinder, which deals with considerably less than the usual amount of vapour, thus saving in power. For one ton of refrigeration 28·4 lbs. of coal per hour are required. W. N. Y. K.

330. *Eight-inch Hardwood Rollers take* 12 *to* 18 *Tons per Foot.* **A. B. McDaniel.** (Eng. News, 80. pp. 122–124, Jan. 17, 1918.)—The article describes a series of tests on wooden rollers. The rollers were hand-hewn out of small timber. Three 8 × 36-in. specimens of each of the following kinds of wood were tested: Hard maple, burr oak, sycamore, and pin or water oak, and one 6 × 36-in. specimen of birch. Each roller was tested for static-compression strength in a 200,000-lb. standard testing-machine. The specimen was bedded on three short 4 × 12-in. oak planks laid transversely, and the load was applied through a single similar transverse plank on top of the roller. Thus only the middle 12-in. length was loaded, while the roller was bedded on its whole length. The results are briefly as follows:—Ten specimens which were "pole" pieces, or rollers cut from trees just large enough to make one piece, failed by shearing vertically. In "quartered" pieces the load was applied in the general direction of the grain and the initial crack was horizontal and extended across the section near its centre. Assuming a factor of safety of 10, the following are suggested as safe loads for "pole" rollers of 8-in. diameter: Hard sample, 2500 lbs.; sycamore, 2500 lbs.; burr oak, 3500 lbs.; pin oak, 3500 lbs. per linear ft. W. J. C.

331. *On the Water Movements in Equilibrium Shafts.* **D. Eydoux.** (Comptes Rendus, 166. pp. 462–464, March 18, 1918.)—The author has shown in a preceding note [Abs. 367 (1917)] that equilibrium shafts transform the pipes upon which they are installed into open pipes at two extremities, and thereby produce the result of diminishing very considerably the water-hammer of the wave. This is replaced by an oscillation of mass, of which the amplitude may be limited either by the inclination or by the augmentation of the shaft section. The present paper embodies a study of the above mechanism when applied to works possessing long feed-pipes, the water movements due to the oscillation being particularly considered. Section I deals with abrupt total closure of the pipe. Section II considers an abrupt partial closure. Section III studies the conditions for an abrupt but complete opening of the pipe. In the concluding Section IV the case of several shafts is investigated. H. H. Ho.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

332. *The Zorzi System for the Electrolytic Production of Hydrogen and Oxygen.* **G. Carrara.** (Elettrotecnica, 5. pp. 86–90, March 5, 1918.)—The electrolytic cells of the new system devised by Zorzi are chiefly characterised by the absence of diaphragms and by the peculiar shape of the electrodes. Each of these is formed of 16 iron bells open at the top, soldered to iron bars and equally spaced, each iron bell being covered by a glass one also open at the top. A larger glass bell covers the column so as to lead the gas into a collector pipe. The gases developed at the surfaces of the iron bells are, therefore, immediately sent through the collector pipe, so that the diffusion of a gas into the other is reduced to a minimum. The cells are made of cement, 16 cells forming a battery. The H and O collector pipes are connected to trunk collector pipes, which lead the gases to the gasometers. The electrolyte is a soda solution of density 1·17. The degree of purity of the gases obtained by the new system is very high: 1·92 % of H in O and 0·34 % of O in H.

Owing to their large content of electrolyte, the Zorzi cells allow of working at very different current densities without the purity of the gases being practically influenced. The new system is employed in the Nieuport-Macchi Works at Varese for oxyhydrogen and oxy-acetylene soldering.

E. B.

333. *Absorption of Sulphur and Oxygen by Copper Kathodes during Melting.* **S. Skowronski.** (Am. Inst. Mining Eng., Bull. No. 135. pp. 645–649, March, 1918.)—The melting of kathode copper, usually containing 99·98 % Cu, would appear to be a simple matter. Owing to the well-known affinity for sulphur, however, so much sulphur is absorbed by the copper during the operation that a long and expensive refining process is required to remove it, and the final product is inferior in purity and lower in electrical conductivity than the original kathode copper. The furnace operations, as now conducted, include the following stages: (1) charging, (2) melting, (3) oxidising period, (4) reduction period, otherwise known as "poling," (5) casting period. Many experiments have been made to obviate the long periods of oxidation and subsequent reduction, with no success.

While the copper first cast will be good, as indicated by the set surface of the bars, it is impossible to hold it to the "tough pitch" condition, and long before the whole charge has been poured the copper will become "over-poled," entailing numerous difficulties.

Sulphur has always been blamed by the furnace-men as the reason why this refining process is necessary. The sulphur absorbed by copper during the melting period comes from two sources: (1) the sulphate left on the kathode sheets in the tank-houses; (2) the fuel. The percentage of sulphates on the kathodes is variable, and depends on the care taken in washing the kathodes after removing them from the electrolytic tanks. In order to study the behaviour of sulphur and oxygen during the refining of kathode copper, samples were taken at ½-hr. intervals from a 500,000-lb. charge of copper. This test was duplicated on another furnace charge of the same weight, using charcoal instead of coke to cover the charge. This charcoal contained only 0·08 % S. Samples taken at regular intervals during the melting and refining

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of copper kathodes show: (1) The total elimination of sulphur during the "oxidation" period and before "poling." (2) The reabsorption of sulphur by the charge when the percentage of cuprous oxide is low enough to allow the reversible reaction. $6Cu + SO_2 \rightleftarrows Cu_2S + 2Cu_2O$ to take place. (3) The advisability and importance of using a low-sulphur coke or charcoal to cover the molten bath during the "poling" and casting periods. J. B. C. K.

334. *Relation of Sulphur to the "Overpoling" of Copper.* **S. Skowronski.** (Am. Inst. Mining Eng., Bull. No. 135. pp. 651–656, March, 1918.)—"Overpoled" copper, as commonly defined, is copper which has been excessively reduced during the poling period of the refining process. Owing to its porosity, such copper is unfit for commercial purposes. The cause of this phenomenon is undoubtedly the lack of oxides in the copper, yet this does not completely explain it. Refined copper of the same "pitch" and "set" varies considerably in oxygen contents, and analyses of overpoled bars also show similar wide differences; moreover, it is possible to melt copper in crucibles so as to obtain bars that are practically free from oxygen, although they show a "tough pitch" and "level set" surface. Experiments carried out by the author on alloys of sulphur and copper show that: (1) Sulphur is a direct agent in the overpoling of copper, the cuprous oxide left in the copper acting only as a neutralising agent for the sulphur. (2) The amount of oxygen present in refined copper, as regulated by the "pitch" of the copper, is automatically controlled by the sulphur, and possibly by other reducing gases present in the copper. [No reliable data regarding the second statement are at hand.] (3) It is impossible to overpole copper by over-reduction, if the copper does not contain sulphur and possibly other reducing gases. Since no reliable data are at hand as to the actual effect of hydrogen and CO on the overpoling of copper, the conclusion as to sulphur must be modified somewhat so as to include the possibility that these reducing gases may also exert some effect, although the over-poling of copper free from sulphur has not been found to be possible in these investigations. J. B. C. K.

335. *Production and Properties of Magnetite Electrodes.* **M. de K. Thompson** and **T. C. Atchison.** (Am. Electrochem. Soc., Trans. 31. pp. 213–217; Disc., 218–219, 1917. Met. and Chem. Eng. 16. pp. 605–606, May 15, 1917.)—Magnetite electrodes were until recently extensively used at Chuquicamata, Chile, as anodes in the electrolysis of acid copper sulphate solutions. Chemically, they withstand the oxidising effect of the current better than any other substance, but they have been practically given up on account of their extreme brittleness and "Duriron" has taken their place.

The aim of the author's work was to see whether this brittleness could not be diminished. With this object in view the addition of copper and other oxides was experimented with; the heat treatment on cooling was varied, and the toughness of the resulting compound magnetite electrodes tested. The method of preparing the electrodes was as follows: A 3·8 cm. hole was drilled to a depth of 16·5 cm. in a graphite rod 5·1 cm. in diam. and 30 cm. long. The whole electrode was held in a vertical position by firebricks with a copper holder at the bottom, where electric connection was made. The other electrode consisted of an electric light carbon, 1·8 cm. in diam. and 30 cm. long. In series with this furnace was a carbon-plate rheostat, an ammeter, and the secondary of a transformer which supplied the heating current. The voltage measured at the transformer terminals was 60,

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and the current was about 200 amps. The electric light carbon was then lowered into the boring in the graphite, until its end touched the bottom; an arc was struck, and the ground magnetite was fed in. This fused in the arc very rapidly, and by watching the process through dark glasses, it was easy to see when to add more magnetite. The boring was thus filled right up to the top, and the electric light carbon was withdrawn gradually during the process.

The method employed to test the brittleness of the anodes consisted in supporting them by two knife-edges at the ends, and applying a load at the centre, gradually increasing it until the specimen broke. This load is a measure of the toughness or brittleness of the material. After some preliminary trials with a larger machine and the use of lead shot in a tin pail as load, a small Riehle testing machine, capable of measuring up to 9000 kg., was found satisfactory when the load was applied very slowly by moving the belt by hand. The loads at which the specimens broke varied from 9 to 159 kg. The results obtained on testing electrodes with a 17·8 cm. span were as follows:—

Per Cent. Copper Oxide.	Load at Breaking-point, Kg.	
	Single Observations.	Average.
0	11·3 17·3 20·4 27·2	19
1	18·2 26·3	22
2	18·2 48·1 50 46·8	39
5	36·3 42·2 47·6 76·2	50
10	52·2 58 1 59	56
20	104 130	117

As regards heat treatment, the investigation is not yet complete, but the effects of annealing for 8 hours, when made with the 5 % copper oxide magnetite electrode, was to increase the breaking load by over 100 %, the average of three tests giving 119 kg. in place of 50 kg. J. B. C. K.

336. *The Permanganate Electric Cell.* **A. W. Warrington.** (Chem. News, 117. pp. 97–98, March 1, 1918.)—Some experiments are described showing the advantages of permanganate as a depolariser instead of dichromate in primary cells. W. R. C.

337. *Temperature Effects in D.C. Meters.* **G. W. Stubbings.** (El. Rev. 82. p. 195, March 1, 1918.)—The temperature error of electricity meters is an important consideration, and the high temperature-coefficient of the Hg meter, in particular, is a serious disadvantage. The accuracy of an unshunted mercury meter is affected about 1 % per 8 deg. C., so that it may easily make 4 % difference in reading in winter if the meter be installed in a living room instead of in a basement. *Case I*—Unshunted meter. Let ω = angular speed of the motor and α temperature-coefficient of resistance of the brake disc. Then $\omega = \omega_0(1 + \alpha t)$, so that if a Cu armature disc be used also for braking, the temperature-coefficient of the meter is 0·428 % per 1 deg. C. This does not allow for the disc being shunted by the mercury, which reduces the actual temperature-coefficient to about ½ % per 1 deg. C. *Case II*—Meter shunted by same material as that forming the meter circuit. The ratio of

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meter and shunt currents is independent of temperature and the temperature-coefficient of the meter is therefore unaffected. *Case III*—Meter shunted by resistance having very low temperature-coefficient δ. If β = temperature-coefficient of shunt and meter it can be shown that $\omega = \omega_0[1 + t(\alpha - \beta n)/(n+1)]$, very nearly, *i.e.* if most of the current passes through the shunt, the temperature-coefficient of the meter is nearly $(\alpha - \beta)$. This condition is usually satisfied in commutator meters; with an Al sheath for the armature coils to serve as brake disc, the temperature-coefficient is about 0·48–0·42, *i.e.* 0·01 % per 1 deg. C. Temperature effects in shunted watt-hour meters and Aron clock meters are too complex to be investigated profitably. Owing to the great number of adjustments available, it should be easy to eliminate temperature error. Until the high temperature-coefficient of the small Hg meter can be reduced by some simple means, the commutator meter will have an important advantage in this respect. R. E. N.

338. *Flexible and Accurate Method for Dielectric Tests.* **C. A. Butman.** (El. World, 71. pp. 502–506, March 9, 1918.)—The series-induction bridge has already been used for the measurement of small changes in the dielectric loss angle [Abs. 2102A (1907)]; but the present writer shows that it may be used equally well for the determination of large changes also. The chief alterations made to give the bridge this greater flexibility are the development of general formulæ for the determination of the geometric capacity, the dielectric loss angle, the total current, and the dielectric energy loss; and also the substitution of Al wire for silver as the vibrator in the Einthoven galvanometer used, whereby its sensitiveness to small changes of inductance is greatly increased. The vibrator was also placed directly in the circuit; reconstruction of the case was necessitated so that the vibrator could be insulated.

The practical limits to the use of the bridge are, on the one hand, its insensitiveness to a change of inductance—which occurs at a potential gradient of less than 3150 volts per cm.—and, on the other hand, the breakdown strength of the material. Since the measurement of dielectric energy loss is the best single test that can be applied to insulation, the value of this form of bridge will be apparent. V. C.

339. *Tests on Oil-switches.* **B. Bauer.** (Electrician, 80. pp. 764–767, March 15, 1918. Abstract from Schweiz. Elektrot. Verein, Bull.) [A translation of the Report dealt with in Abs. 880 (1917).]

340. *Abac for Determination of Resistances in Parallel.* **A. Castex.** (Rev. Gén. d'Él. 3. pp. 424–426, March 23, 1918.)—Describes a simple abac consisting of four concurrent lines, on which scales can be marked off, for the rapid determination of the combined resistance of any number of conductors in parallel. N. W. M.

341. *Testing Electric Ignition Apparatus.* **E. A. Watson.** (Engineering, 105. pp. 379–380, April 5, 1918.)—The author points out that the readings of a thermal galvanometer are not a perfect criterion of the efficiency of a magneto, since the capacity of the machine for producing ignition depends on the initial current component of the spark, which latter depends partly upon the capacity of the part of the circuit near the spark-gap. C. A.

342. *Permeability of Iron Stampings by Ewing's Method.* **F. Shaw.** (Electrician, 80. pp. 787–790, March 22, 1918.)—In the double bar and yoke method employed, two magnetising coils form the opposite sides of a rectangle, the

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remaining sides being completed by the yokes. The stampings to be tested are in the form of flat strips, and lie within the magnetising coils and are firmly clamped within the yokes. By using two sets of magnetising coils, one twice the length of the other and with twice the number of turns, the reluctance of the gaps and yoke can be allowed for. In one case the secondary coils were wound over the brass formers and underneath the magnetising turns, and in another case round the iron strips at the centre. The ballistic galvanometer is connected in series with the search coils, the coil of a Hibbert magnetic standard, and a resistance box. In working, the number of turns on the specimen is so arranged that for high values of flux density the full scale deflection is produced on the galvanometer when the magnetising current is reversed; also the resistance of the circuit is made such that the flux density of the specimen is exactly 100 times the throw. Details relating to the use of the Hibbert standard are furnished, and the effect of surface scale on the specimen in changing its density, resistivity, and permeability is discussed. A given magnetising force was found to produce 4 % more flux with clean iron than with iron covered with scale. The value of the intensity of magnetisation obtained for the clean iron was 1743. B-H curves for the specimens are shown. [See also Abs. 118A (1916).] G. E. A.

343. *General Method of Solving Electrical Problems.* **W. Deutsch.** (Archiv f. Elektrot. 6. pp. 225–262, 1918.)—A mathematical dissertation on methods of solving electrical problems that lead to total or partial differential equations. The novel manner of handling the differential equations is based on regarding a phenomenon not as a series of instantaneous values, but "as a whole." The constants of integration lose the indefiniteness that they possess as solutions of the differential equations. The application of the method is illustrated by the solution of a number of problems in different branches of electrotechnics, such as the switching of circuits, damped oscillations, short-circuits, etc. A. J. M.

344. *German Substitutes for Copper.* **F. Niethammer.** (Elektrot. u. Maschinenbau, 36. pp. 37–44, Jan. 27, 1918.)—In consequence of the war, the connections to bus-bars on switchboards and for the various pieces of apparatus have had to be made of substitutes for copper, mainly Al, Zn, Fe, and an alloy called "elektron," which has a density of 1·8, and is mainly composed of Mg. The author considers mathematically the general principles on which the sizes of these conductors should be determined.
W. H. S.

345. *Plant Growth under Artificial Illumination.* **J. L. R. Hayden** and **C. P. Steinmetz.** (Gen. El. Rev. 21. pp. 282–286, March, 1918.)—Only one set of experiments is described. They were made in the winter 1916–17 in an orchid-house with gas-filled Mazda lamps as source of light. Five of these 500-watt lamps were suspended in a row, 86 in. above the ground, 17 in. apart from each other; the good black soil, 5 ft. by 9 ft., was planted with Henderson's dwarf wax-bush beans; the check-test was made with a box 86 in. square. The 5 lamps were kept burning day and night for 44 days, consuming 2·5 kw.; the two lamps were kept alight for 29 more days; the hothouse temperature, 18° to 20° C., was raised by 2 deg. by the heat of the lamps over the experimental bed. The beans in the check-plot received only daylight. The power consumption over the bed was 55 watts per sq. ft., and the intensity of illumination about 700 lumens per sq. ft. of ground; direct sunlight illumination was thus approached. The rate of plant growth and

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development was nearly doubled, but at high cost. Yet this artificial illumination might repay itself for raising products temporarily of high value for special purposes. H. B.

346. *Comparative Tests of Steam and Electric Bakers' Ovens.* **O. Hasler.** (Schweiz. Wasserwirtsch. 10. Nos. 3 and 4, 1917. Elektrot. u. Maschinenbau, 35. p. 22, Jan. 13, 1918. Abstract.)—Tests were made of two steam bakers' ovens, one a draw-plate oven and the other a Vienna sloping sole oven, and of two electric ovens of corresponding types. All four ovens had two compartments, one above the other.

The results are as follows :—

	Coal in kg. per 1 kg. bread.	Kg. cals. per 1 kg. bread.
1. Steam draw-plate oven	0·212	1060
2. Steam Vienna oven	0·191	955
	Kw.-hrs. per 1 kg. bread.	**Kg. cals. per 1 kg. bread.**
3. Electric draw-plate oven without thermal storage	0·393	822
4. Electric Vienna oven with thermal storage	0·417	359

The time of experiment for the first three ovens was 6 days, and for the last oven 4 hours. The loading of the electric oven No. 3 was 90 kw. and No. 4 only 50 kw. In the last oven, which was directly heated, of 301 kw.-hrs. used for baking 722 kg. of bread, 100 kw.-hrs. were employed in heating up. If the time of experiment had been longer, the consumption of electric energy would have been 0·347 kw.-hr. and the heat-consumption 298 kg. cals. per 1 kg. of bread. The indirectly heated electric oven with thermal storage is equally efficient, the average for the two being 350 watts or 300 kg. cals. per kg. bread, as compared with 0·2 kg. fuel or 1000 kg. cals. per 1 kg. bread for steam-heated ovens. C. A.

347. *Tests of Electric Range Efficiency.* **R. G. Kloeffler.** (El. World, 71. pp. 357–359, Feb. 16, 1918.)—These tests were made in 1917 at the Kansas State Agricultural College. The efficiency of a surface-heating unit was obtained as follows: One quart of distilled water at a temperature of 60° F. was placed in a covered utensil on a unit and current at 110 volts was turned on until the water rose nearly to the boiling-point (206° F.), as registered by a Hg thermometer, the electric energy consumed being recorded by a watt-hour meter. The efficiency is then = [lbs. water × change in temperature in degrees Fah.] ÷ [3415 × kw.-hrs.]. If the water boils away for any appreciable time, the water is re-weighed and the efficiency can be obtained from the following formula: Efficiency = [lbs. water × change in temperature + lbs. water evaporated × latent heat of evaporation] ÷ [3415 × kw.-hrs.]. Tests of seven units are given, of which three have the conductor enclosed and four are of the open or radiant type. In the latter, one has the conductor arranged as a six-point star, another in parallel lines, a third in a flat spiral, and the last in the form of a grid. The utensils

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were: a bluish-grey granite kettle 6-in. diameter at the bottom; an Al kettle 6-in. diameter having a bright lustre and a perfectly flat bottom; an Al kettle same as above except that it was discoloured with use and dented at the bottom; a new Al fireless cooker pan 8-in. in diam. with a perfectly flat bottom; an agate granite pan and a white granite pan each 8-in. in. diam. at the bottom. All utensils were fitted with covers.

Type of Unit.	6-in. Granite.	8-in. Granite (Agate).	6-in. Al. (New).	8-in. Al. (New).	Average for Granite.	Average for Al.	Average for all.
Open	35·6	42·7	33·3	37·5	39·15	35·4	35·27
Open	43·6	52·4	33·3	43·5	48·0	38·4	43·2
Open	36·8	46·2	32·2	43·3	41·5	37·5	39·5
Open	42·4	47·2	37·2	47·9	44·8	43·55	43·67
Average.....	39·6	47·1	34·0	43·05	43·35	38·45	40·91
Enclosed ...	29·7	43·2	36·6	49·1	36·45	42·85	39·65
Enclosed ...	46·4	41·2	53·8	48·7	43·8	51·0	47·4
Enclosed ...	29·5	41·5	37·1	54·9	35·5	46·0	40·75
Average ...	35·2	41·97	42·33	50·9	38·6	46·6	42·6%

Type of Unit.	6-in. Al (New).	6-in. Al (Old).	8-in. Al (Covered).	8-in. Al (Open).	30-min. Test. Granite.	30 min. Test. Al.
Open	33·3	28·4	37·5	34·4	58·9	51·5
Open	33·3	33·6	43·5	34·2	58·7	51·2
Open	32·2	31·4	43·3	31·4	55·0	55·8
Open	37·2	32·8	47·9	39·3	55·7	60·8
Average	34·0	31·55	43·05	34·8	55·07	54·8
Enclosed ...	36·6	22·9	49·1	42·4	60·0	57·8
Enclosed ...	53·3	37·8	48·7	43·75	50·3	68·5
Enclosed ...	37·1	25·2	54·9	51·5	57·5	72·9
Average	42·3	28·6	50·9	45·9	55·9	68·1
General Average ...	—	—	46·97%	40·35%	—	—

The original paper includes some further details and curves showing efficiencies at stated intervals of time from the turning on of the currents.

C. A.

348. *Tests of Electric Ovens.* **R. G. Kloeffler.** (El. World, 71. pp. 408–410, Feb, 28, 1918.)—This paper gives particulars of radiation tests made on a series of eight ovens of different sizes, and includes curves showing the constant internal temperature for different inputs of electric energy, cooling curves from a common temperature, radiation in watts per 1000 sq. in. of surface, radiation in watts per cub. ft. of contents, and ratio of energy con-

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sumed to oven temperature. It was found that the ovens which required the most energy to heat were the ones that retained their heat the best, so that for operations that require only a short time they are not the most efficient, although they are the best for the longer operations, such as baking bread or roasting. Particulars are given of the eight ovens, and also a table showing the kilowatts required for preheating and keeping the ovens at the proper temperature for the three operations of baking biscuits, baking bread, and roasting. C. A.

349. *Selection of Steel Mill Auxiliary Motors and Control.* J. D. Wright (Am. I. E. E., Proc. 37. pp. 255–260, March, 1918.)—The author describes manipulators for blooming mills, which consist of side guards and lifting fingers, the former being used to guide the bloom into the proper groove in the rolls, while the latter are used to turn the bloom over. The mechanical lay-out and operation of the manipulators are described, and conclusions are drawn as to the most suitable motor and control gear. As regards the side-guard drive, two motors (one on each side of the mill) may be geared through slip clutches to a common shaft carrying four pinions engaging with four racks. Two of the racks are attached to a guard on the entering side and two to a guard on the delivery side of the mill. The remaining two guards are similarly operated by a second pair of motors. During rolling, the operation of the guards consists of many fast, short movements to and fro across the table, and it is possible for the guards to come together or against the ingot at full speed. The slip clutch prevents damage should such collision occur. In the case illustrated, the motor equipment for the side guards consists of four 80-h.p. series motors, connected two in series. Series motors are well adapted to the rapid acceleration and retardation required by the side guards, but compound motors are sometimes used to obtain dynamic braking. In the present case, the control for each pair of motors is reversible, and is so arranged that resistance is connected permanently in series with the motor armatures; this acts as a buffer, reducing the shock when the guards jam together or against the ingot. A one-point reversible master controller is used for each pair of motors. Limit switches cut off power when the side guards reach the edge of the table. Track type limit switches, operated by rack are simple and positive in action.

The fingers used to turn the bloom over, move to and fro with the guard. The mechanism used to operate them is such that ½-rev. of the main driving shaft produces a complete up-stroke of the lifting fingers. Another ½-rev. returns the fingers to their initial position, hence the motors may be either reversible or non-reversible. An equipment is illustrated in which two 50-h.p. series motors, in series, work non-reversing: each throw of the master controller produces a complete up and down motion of the fingers. At the end of the down stroke the motors are stopped automatically by a limit switch which cuts off power and completes a dynamic braking circuit. Control connections are simplified by using a compound motor, if dynamic braking is required, using a reversing motor. Solenoid brakes are needed with reversible, but not with non-reversible equipment.

For the side guards a reversing motor must be employed, but the motors may be series- or compound-wound, and dynamic braking and solenoid brakes may or may not be used. There are many possible combinations of all the means and methods available, and it is not yet possible to say which is the best combination. R. E. N.

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350. *Electrical Reversing Rolling Mill.* (Engineering, 105. pp. 282–284, March 15, 1918.)—Gives a brief illustrated description of an electrical reversing rolling mill installed at the Jarrow works of the Palmer Shipbuilding and Iron Co. by the British Westinghouse Co. Two important features requisite for this type of plant are, first, that the motor should be capable of dealing with the excessive peak loads that occur; and second, that the generator of the flywheel set should be able to stop, and also accelerate, the mill motor very rapidly. In the present plant the mill motor deals with a torque of 140 metric tons at a speed of 40 revs. per min., well above the specified requirements, and when rolling 4-ton ingots 20 in. × 18 in. to 6 in. × 6½ in. an output of 85 tons per hour is obtained. The arrangement of electric controls and gear for accelerating and decelerating rapidly is shown in a diagram and its working described. The flywheel is solid throughout, being designed to secure the maximum of energy in a given weight of steel without excessive stresses. Some data are presented, viz.—

Mill motor:	2500 h.p., R.M.S. rating.
„ „	8500 h.p., peak.
„ „	0/40 revs. per min., Ward Leonard control.
„ „	40/75 „ „ „ rheostatic control.
„ „	Forced ventilation with filtered air.
Generators:	Two, 1000-kw.
Induction motor:	1850 h.p.
„ „	600 r.p.m. synchronous.
„ „	Supply, three-phase, 40-∼, 5750 volts.
Flywheel:	85 tons, peripheral speed about 22,500 ft. per min.

W. N. Y. K.

351. *Operating Characteristics of Motor-driven Planers.* **C. E. Clewell.** (El. World, 71. pp. 87–90, Jan. 12, 1918.)

352. *Applications of Motors to Steel-mill Operations.* **C. E. Clewell.** (El. World, 71. pp. 250–258, Feb. 2, 1918.)

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GENERATORS, MOTORS, AND TRANSFORMERS.

353. *Graphical Method of Predetermining the Heating of Electric Machines.* **G. Gut.** (Schweiz. Elektrot. Verein, Bull. 9. pp. 35–53, Feb., 1918.)—The various analytical and graphical methods of calculating the temperature-rise curves for a machine from the exponential equation are reviewed. A new graphical method is then described, in which "nomographic" diagrams are employed. These diagrams, devised by the French mathematician d'Ocagne, have the object of evaluating expressions in which relations appear between more than two variables. The process is applied to the case of machines that are intermittently loaded and enables measurements below the max. permissible load of the machine to be used to predetermine the parameters, the direct measurement of which would necessitate overloading the machines. A. J. M.

354. *Commutation in A.C. Machinery.* **M. C. A. Latour.** (Am. I. E. E., Proc. 37. pp. 169–194, Feb., 1918.)—In previous publications and patent specifications, the author has contended that if $L\omega$ is the inductance per phase of a polyphase winding when stationary, the inductance becomes $L(\omega - \omega_1)$ when the armature turns with an angular velocity ω_1 in the direction of the field. Consequently the value becomes zero at synchronism and the winding acts as a capacitance above synchronism. This view has been questioned by many writers, and particularly by Leblanc. This controversy is now renewed, and the statement is found to be true when the distribution of the flux on the surface of the armature is sinusoidal. If the distribution of flux is considered on the surface containing the axes of the conductors in the slots, then the inductance is $L(\omega - \omega_1 X)$, where $X = 1$ for a sinusoidal distribution and $X = 8/\pi$ for a triangular distribution of the flux, the winding being for two-phase current. Expressions of this type are evaluated for windings with different numbers of phases. Discussing commutation, it is concluded that this is assisted by the production of a perfect revolving field in a polyphase commutator motor. In the case of the single-phase commutator motor, the revolving field can be produced at synchronism by placing auxiliary short-circuited brushes at right angles to the main brushes. The formation of a perfect rotating field is improved by using fractional-pitch windings on the rotor and a sinusoidal distribution of the conductors on the stator. A. J. M.

355. *Graphical Determination of the Direct and Transverse Inductance of Alternators.* **A. Blondel.** (Comptes Rendus, 166. pp. 323–329, Feb. 25, 1918.)—The method is a graphical evaluation of the direct and transverse inductances of an alternator, taking into account the shape of the saturation curves of the various parts of the magnetic circuit. A. J. M.

356. *Standard Shaft Ends for Electric Motors.* (Rev. Gén. d'El. 3. pp. 543–544, April 13, 1918.)—Electric motors are now used in such numbers to drive all classes of machinery, that standardisation of the motor shaft ends is of great importance to both manufacturers and users of motors. On the one hand, it relieves the motor user of the necessity of adapting his machines to a variety of motors, and, on the other hand, it relieves the motor manufacturer of the necessity of providing a large variety of shaft sizes of which an adequate stock of spares cannot be reasonably maintained. According to this paper, "electrical manufacturers have held a number of conferences" and agreed upon standard values for certain external dimensions, the standardisation of which will not interfere with the nature and individuality of the products of

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various firms. A table of shaft-end dimensions is presented which is to apply to all fresh constructions excepting traction motors. The aim in view is to establish gradually the same shaft-end details and dimensions in all motors of given power, whatever their make; this would eliminate the cost and delay of making special shaft ends for individual motors or, what is worse, altering the shafts of completed machines. The table covers 27 shaft diameters from 10 to 200 mm., and gives values for the overall length of the end piece of the shaft (cylindrical and conical seatings); key dimensions; and maxima for the washer diameter and threaded extremity of the shaft used in conjunction with a nut when the shaft seating is conical. R. E. N.

357. *Use of Transformer with Series A.C. Motor.* **M. Ernst.** (Elekt. Zeits. 38. pp. 561–564, Nov. 29, 1917.)—The machine under consideration is the 8-phase series motor with six brushes on its commutator. This machine usually has a transformer, which may be connected in front of the whole machine or between the armature and the field. The latter arrangement is found to be preferable, as the transformer is smaller and cheaper, and as the operating characteristics of the motor are improved in several respects. In the first place the light-load speed is limited, so that the motor cannot race as it would do if the transformer were connected in front of the stator and rotor windings, and in the second place saturation of the transformer iron stabilises the speed on heavy loads. The extent to which the transformer acts in this manner depends on the brush position. The above effects are deduced from vector diagrams of the motor, and curves are constructed showing the relations, two by two, between the torque, speed, and brush shift, and also for the power factor of the motor, both for the case when the transformer is connected in front of the whole machine and intermediately between the stator and rotor windings. A. J. M.

358. *Factors affecting Vapour Rectifier Performance.* **W. Tschudy.** (El. World, 71. pp. 403–405, Feb. 23, 1918.)—The author compares his experimental data and conclusions with those obtained by the Reichsanstalt from investigations with Hg-vapour rectifiers. A brief statement is given of the reasoning and tests on which the Reichsanstalt based the following conclusions:—(1) The watts loss in a rectifier bulb can be represented by the voltage drop in the Hg arc. (2) This loss decreases slightly with increased anode current and (3) is independent of a.c. wave-form and frequency.

Tschudy considers these conclusions to be based on incomplete data and to be incorrect. His own conclusions are that bulb loss varies greatly with wave-form, frequency, and anode current. It is incorrect to consider the voltage drop in the Hg arc as a loss, and this drop varies about 20 % according to the anode current. Second and third harmonics in the wave-form affect the bulb loss and efficiency very considerably. The author considers that the efficiency of the Hg rectifier is generally estimated too high. Results obtained from tests with direct-current Hg arcs are not applicable to pulsating-current Hg rectifiers used in conjunction with transformers. Curves given in the original show: (1) The load characteristics of a rectifier with constant primary voltage and normal frequency. (2) Bulb and rectifier efficiencies at different outputs and with three wave-forms. (3) Load-efficiency curves of transformer, bulb, and rectifier at 50 cycles and constant primary voltage (110 volts). (4) Effect of wave-form on bulb losses. (5) Anode and rectifier currents as a function of output with various wave-forms. (6) Relation between bulbs and rectifier efficiencies at various frequencies. (7) Bulb losses as function of output with three different wave-forms. R. E. N.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

359. *Voltage Variations in Three-wire A.C. Transmissions.* **J. Teichmüller.** (Elekt. Zeits. 88. pp. 533–534, Nov. 8; 544–546, Nov. 15, and pp. 555–558, Nov. 22, 1917.)—In a previous article [Abs. 780 (1916)] the author developed a vector diagram for 3-wire a.c. transmission lines on the assumption that the wires were mounted at the corners of an equilateral triangle and that the power factor for the line was independent of the magnitude of the loads on the two halves of the line. On this assumption the locus of the end of the vector representing the voltage drop was a straight line. The more general case is now considered, not making the above assumption, and the locus is found to be a parallelogram. The shape of this parallelogram is investigated for various sections and arrangements of the line conductors. New formulæ are obtained for the variations of voltage in terms of the relative voltage drop, the power factor of the line, and receiving apparatus. **A. J. M.**

360. *Simplified Transmission-line Calculations.* **T. A. Wilkinson.** (El. World, 71. pp. 244–248, Feb. 2, 1918.)—The expressions for the current I_0 and voltage E_0 at the receiving end of a line of length l with constants per unit length given by resistance r, reactance x, leakage conductance g, and capacity susceptance b are $I = I_0 \cosh la + E_0(1/z_0) \sinh la$ and $E = E_0 \cosh la + I_0 z_0 \sinh la$, where $a = \sqrt{[(r+jx)(g+jb)]}$ and $z_0 = \sqrt{[(r+jx)/(g+jb)]}$, and I and E are the current and voltage at the sending end. These expressions are somewhat cumbersome to manipulate, and it is shown how they may be transformed for simplicity. Writing $I = I_0(a_1 + ja_2) + E_0(c_1 + jc_2)$ and $E = E_0(a_1 + ja_2) + I_0(b_1 + jb_2)$ and comparing the coefficients a_1, a_2, b_1, b_2, c_1, c_2, with the series expansions of the hyperbolic functions it is shown that to a first approximation we have $1 - a_1 = (xb/2)l^2$, $a_2 = (rb/2)l^2$, $b_1 = rl^2$, $b_2 = xl^2$, $c_1 = -(rb^2/6)l^3$, $c_2 = l^3$. The exponents of l may be chosen so as to give *exact* values (not approximations) for given values of r, x, b, l. This is effected by a number of charts. These charts are drawn for a line with $r = 0{\cdot}1$ ohm, $L = 2{\cdot}11$ millihenrys, $C = 0{\cdot}0145$ mfd., and give the exponents for various frequencies and length of line. The effects in the variations in the values of r, L, and C from the selected values within the limits met in practice is very slight in affecting the values of the exponents as given in the charts. **A. J. M.**

361. *Intermittent Arcing to Earth.* **W. Petersen.** (Elekt. Zeits. 88. pp. 553–555, Nov. 22, and pp. 564–566, Nov. 29, 1917.)—When an arc takes place to earth on a transmission line a charge is left on the conductor after the arc has broken. This charge acting together with the line voltage enables the arc to strike again, and the process is repeated, with continuous building up of voltage to a max. value. This may reach 3 to 4 times the normal phase voltage on the sound phases and 3 to 3·7 times the normal value on the faulty phase in the case of 3-phase systems. At the same time dangerous surges are set up at each re-striking of the arc. These calculations explain why it is that such surprising lengths of arc are sometimes maintained to earth. It is shown that the charge left on the conductor after the rupture of the arc gives rise to a voltage that is almost steady and decreases only very slowly. In the case of a 10-kilovolt overhead line the fall was about 30 % in

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wet weather in the first half-period and in a 50-kilovolt line it was 8 to 4 % in dry weather. The calculations of the max. voltage reached are carried out for single-phase and 3-phase systems with different ratios between the capacities, between phases, and between phases and earth. The max. voltages are greater in 3-phase than in single-phase lines, and this is in accordance with the greater difficulty found in practice in extinguishing the arcs on 3-phase lines. A. J. M.

362. *Reducing the Consumption of Electricity.* **G. Dettmar.** (Elekt. Zeits. 39. pp. 73–76, Feb. 21, 1918.)—The author, who is the representative of the Coal Controller in Germany, discusses the means by which the consumption of electricity may be reduced and coal be saved. The total output of the German generating stations has increased greatly during the last few years, mainly owing to the substitution of machinery for manual work. As the output of coal cannot be correspondingly increased owing to the scarcity of labour, it is necessary to face the fact that the available quantity of coal is strictly limited. The number of units generated by the German stations was 1·5, 5·1 and 10 milliards in the years 1909, 1913, and 1917, and the total has increased to six times its value in 8 years. It is true that the coal consumption of the electric stations is only a small proportion of the total consumption of the country, but nevertheless a saving of appreciable amount could be effected by them. The proportion of the lighting to the total output has decreased enormously during the past 25 years, this ratio being 0·80, 0·41 and 0·10 in the years 1895, 1905, and 1915. At the present time it has sunk to 0·08. This is due to great increase in motor load. It follows that coal saving is impossible without economy in motor operation. This may be effected by more efficient methods of manufacture. A considerable output is taken by agricultural industries, and one means of saving in this class of load is by cutting off the supply during certain periods of the night, so as to save the no-load losses. Tramway systems are important consumers of electrical energy. Saving is difficult in large towns and easier in small ones. It may be effected by discontinuing certain services, particularly in the outskirts, by lengthening the distances between stopping-points and by discontinuing the system of stopping by request that is still adopted in some small towns. So far as the lighting load is concerned, it is pointed out that a greater saving is possible than might at first sight be expected in view of the small proportion of the lighting to the total load. This is due to the peak loads that are obtained and methods that have the effect of smoothing out the peaks will have an important influence on the coal consumption. A list of such methods is given, including changes of working hours, theatre hours, restriction of lighting of shops, hotels, restaurants, streets, public galleries and museums, economy in the home, substitution of metal-filament lamps for carbon-filament lamps. The peak would be further limited by stoppage of motors at certain hours, restriction in the use of lifts at certain periods of the year and times of the day, by suitable fixing of the time of breaks between working shifts and luncheon hours, by spreading of the working hours into the night and over Sundays, and by issuing regulations governing the times at which agricultural work may be performed. The same object may be furthered by restricting the lighting and heating of tramcars and limiting the services and regulating the stopping-places. The article concludes with an appeal to the users of electricity to limit their consumption, and details are given of the means by which individuals may assist in effecting economies.

A. J. M.

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363. *Reduction of Coal-Consumption in Power Stations.* **B. H. Blaisdell.** (El. Rly. J. 51. pp. 308–311, Feb. 16, 1918.)—This describes an experiment which has been tried in a power station in Manila, where the employees were promised one-half of the money saved in coal economy. The details of the plan are given, and the system is described by which zeal was kept within the bounds of discipline. A great improvement is said to have been effected.

W. H. S.

364. *The Fertiliser Industry and its Power Requirements.* **J. E. Mellett.** (Gen. El. Rev. 21. pp. 96–110, Feb., 1918.)—Costs of manufacture in the fertiliser industry have risen more rapidly than selling prices, and the author discusses electrification as a means of increasing profits again. He deals in detail with the power requirements of the industry, and all the principal types of manufacturing machinery from that which merely mixes ingredients to the equipment used to make and prepare all the necessary substances, such as sulphuric acid, limestone, ochre, or felspar fillers. Some fertiliser plants work at good load factor all the year round, but most of them work at reduced load during the summer. After discussing the function and constituents of fertilisers the author reviews the sources of materials and describes their manufacture or preparation in some detal, and gives special attention to the mechanical drives and power requirements. Alternating-current motors and equipment are used almost invariably.

The types of plant employed include small dry-mixing plants, filler plants, combination cotton-seed oil and fertiliser plants, and acid and non-acid making plants. A plant mixing about 100 tons a day needs 80–85 h.p. for the mixer and 15–20 h.p. for the elevator, reel, and screen. The working period is 5 to 7 months in spring and autumn and an internal-combustion engine is generally employed. The max. demand on hand-mixing plant is 15 kw. for ½ hr., with a consumption of 1½–2 kw.-hr. per ton sacked and an annual load factor of 8 %. With power-operated mixing plant the max. demand is 20–30 kw., the consumption 2½ kw.-hr. per ton sacked, and the annual load factor from 5 % up to 12 % in large plants.

Filler plants supply fertiliser manufacturers with ochre, feldspar, and crushed limestone. A specific plant produces 40,000 tons of filler or dryer per year with a consumption of 3·3 kw. per ton, a ½-hr. max. demand of 75 kw., and a 24-hr. load factor of 20 %; heaviest running is between Jan. 1st and May 1st.

Treating insoluble phosphates with H_2SO_4 is one of the most important processes, and for it the phosphate must be ground to a fine dust. The power required varies with the type of mill, number of grinders, and type of conveyors and elevators. Belt-driving guards against damage by clogging, particulars of equipment, and speed and horse-power of drive are given in the original. The Raymond mill, including fan, requires 100 to 125 h.p. and 15 to 16 h.p. (h.p.-hrs. ?) is used per ton of 95 %, 90-mesh dust. Machines for mixing the dust with acid vary from ½ to 2 tons' capacity; a 1-ton mixer requires 8 h.p. and a 2-ton mixer 12 h.p. Fan equipment to remove CO_2, Cl, and F from one mixer requires 7½ to 10 h.p. The average power consumption of a number of acidulating plants is 7 to 8 kw.-hrs. per ton.

The 1916 production of sulphuric acid in the United States was 5½ million tons (35 % increase on the pre-war figure). Fans used to handle the corrosive gases involved in sulphuric acid manufacture have displacements from 5000 up to 22,000 cub. ft. per min. (against 2 oz. pressure) and power consumption from 5 to 35 h.p. Air compressors are used to drive acid from

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the storage tanks, and these need 15 to 40-h.p. motors. Electric driving is especially appreciated because it reduces to a minimum the risk of interruptions in service. The power consumption ranges from 4 to 18 kw.-hrs. and averages 9 kw.-hrs. per ton of acid.

Bagging machines range from 15 to 75 h.p., and from 2 to 10 machines may be used. Conveyors and elevators needing 35 h.p. may be used with the largest bagging machinery. Squirrel-cage motors are generally employed, with slip-ring motors in exceptional cases. Electric trucks may be used to carry material to the mixers and baggers. These trucks may be of 2 tons' capacity and may be filled by electric shovel. Mixing, bagging, and shipping consumes 0·8 kw.-hr. per ton, up to 2·2 kw.-hrs. where power trucks are used between baggers and freight.

The percentage power distribution in acid-making plants is: Rock grinding and wet mixing 37½ to 45 % ; acid making 35½ to 40 % ; mixing, bagging, and shipping 9 to 19 % ; lighting and miscellaneous 4½ to 8 %. In a plant where acid was bought, 81 % of the total power was used in the rock grinding and acidulating department. There is no question that purchased energy is more economical than private power plant. Conditions are unfavourable to insulation, and 440 or 550 volts is the best working pressure, all things considered. The motor windings should be specially impregnated. Triple braid weatherproof wiring on poles is recommended for distribution, wires within buildings being covered with 30 % rubber treated with acid-proof paint. Lighting is very defective in most existing plants; from 1 to 3 candle-ft. should be provided. R. E. N.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

365. *Passenger Locomotive for Chicago, Milwaukee and St. Paul Railway.* (El. Rly. J. 51. p. 237, Feb. 2, 1918. Electrician, 81. pp. 4–5, May 3, 1918.)—This locomotive weighs 266 tons. There is a single cab on two main running gears, each having a 4-wheel guiding truck, three driving axles in a 16 ft. 9 in. rigid wheelbase, and 2-wheel trailing truck. The driving wheels are 68 in. in diam. The centre of gravity of the main running gear, including motors, is 41½ in. above the rail. The one-hour rating is 4000 h.p., and the continuous rating 3200 h.p.: normal speed on level track is 60 miles/hr., and on a 2 per cent. gradient the speed is 25 miles/hr. with a 950-ton train. There are six 1500-volt twin motors on one unit, and there are 9 running positions without rheostatic loss. W. H. S.

366. *Split-phase Locomotive on the Pennsylvania Railroad.* **A. J. Hall.** (Elect. J. 14. pp. 409–412, Oct., 1917. Electrician, 80. pp. 722–724, March 1, 1918. Abstract.)—Single-phase current is taken from the overhead wire, and transformed by a rotating phase-converter which feeds 3-phase induction motors. This phase-converter is a motor-generator producing a supply of power with a voltage displacement of 90 deg. from the transformer secondary voltage: this 2-phase energy is then converted into 3-phase by the Scott connections. A diagram shows the connections in detail. A small single-phase motor brings the phase-converter to synchronous speed. Power is supplied to each of the four motors through five electro-pneumatically operated unit switches, which are also used to interchange connections of two of the phases in order to reverse the direction of motion. Each pair of motors is connected in cascade on the low speed: the motor primaries are connected in parallel on the high speed, each secondary being connected to a regulating liquid rheostat. The

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max. voltage across the electrodes of these rheostats varies from 850 to 1000. Various particulars and drawings are given of these liquid rheostats and the methods employed to cool them. The regenerative braking does not require any extra control equipment: this is due to the inherent characteristics of the induction motor. The manipulation of the air brakes requires some experience: otherwise the equipment is foolproof. W. H. S.

367. *Technical Features of the Langenthal-Melchnau Electric Railway.* F. Marti-Ziegler. (Schweiz. Elektrot. Verein., Bull. 9. pp. 1–8, Jan., 1918.)—The principal technical features of the Langenthal-Melchnau Railway are described; this line forming a branch from the Langenthal-Oensingen narrow-gauge railway which has been operating with direct current at 1000 volts since 1907. The railway has been equipped during the war (1915–1917). The new line makes a long circuit via Roggwil and St. Urban to serve these places and to secure favourable gradients. The route length is 12 km.; gauge 1 m.; max. gradient 4·5 %; minimum radius 60 m. Phœnix rails, 24·2 kg. per m. are used for most of the track on 29·7-kg. iron sleepers 0·772 m. apart; grooved rails of 30·8 kg. per m. at street-crossings. Two copper wires, 6 mm. diam., are taken under the fishplates as bonds and oxy-acetylene welded on both sides; cross bonds and point bonds are of 8-mm. wire. The rolling stock includes one 20-ton locomotive with four 75-h.p. motors; one 4-axle, 24-ton motor coach, 4 × 75 h.p., seating 30; one 2-axle, 14·7-ton motor coach, 2 × 75-h.p., seating 24; and a number of trailers and goods wagons. The automatic couplings save time and risk.

The railway is supplied from the Wynau electricity works, but the shortest practicable transmission route thence to Roggwil is 4·5 km. It was proposed to use 2 × 125 mm.² copper conductors for lead and return (4 in all, costing 70,000 fr. complete). The assumed max. load was 400 kw., corresponding to 255 volts drop (from 1100 to 845 volts). The average load is 26 kw. and the max. to date 850 kw. A substation at Roggwil would involve an 8000-volt transmission line, and the cost of energy at the railway would be heavier than under the first scheme. Mercury rectifiers were considered to be insufficiently tested for use under the conditions here existent, and the d.c. transmission at 1100 volts was therefore adopted. The substation equipment includes two 100-kw. and one 250–350-kw. rotaries and a 150-amp.-hr. buffer battery.

Max. train weights are 46 tons for passengers, 84·4 tons for goods. Max. speed, 40–45 km./hr. on gradients up to 2·5 %; 25–30 km./hr. on gradients up to 4·5 %. It was originally proposed to use two 8-mm. hard Cu wires along the whole track, and a feeder of the same size between the main feeder points at 4·53 km. and 9·15 km, Resistances—Two 8-mm. Cu wires 0·175 ohm/km.; three ditto, 0·117 ohm/km.; track, including 30 % for joints, 0·031 ohm/km. Between March 1915, and May 1916, the price of copper rose so much that the 84 tons of track conductors required would have cost 70,000 fr. more than anticipated; also the delivery period from America was uncertain. It was therefore decided to use two 8-mm. galvanised iron wires as overhead contact lines, and Al conductors as track feeders, 240 mm.² in the central section and 160 mm.² at each end of the line; connections to the iron wires every 200 m. run. The transmission line from Wynau to Roggwil consists of two 200 mm.² Al conductors (19—3·65 mm. wires in each) in both lead and return. The iron contact wires are set 120 mm. apart and zigzagged so as to wear the contact bows uniformly. A sag of 350 mm. in 30 m. span give a factor of safety of 5 at 20° C. Al wire

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is too soft for use as trolley conductor; on the other hand, the conductivity of the iron wire used is neglected in design, dependence being placed entirely on the Al track feeders.

The contact piece on the collector bow is of 8·5 × 8·5 cm. angle iron with rounded corner. This is very cheap and durable; it lasts twice as long as the Al bows on the narrow-gauge railway where the trolley wires are of copper. With iron conductors, sparking destroys an Al bow in a few journeys, but a soft-iron bow yields almost sparkless operation.

The track conductors are carried by a ¾-in. gas pipe stayed by a single 6-mm. steel wire. Both tube and wire are galvanised and are attached by collars to bracket insulators on the pole, so the whole line bracket is free to rotate in the direction of the line and thus equalise sag. This arrangement is very cheap and simple and has given satisfactory service on the narrow gauge railway. Gas pipe is used for both parts of the bracket on curves. Anchor brackets are used every 500 m. Cheap sleeper foundations are used for the poles. Telephone lines are of 3-mm. galvanised Fe wire.

The total cost of the scheme has been about 110,000 fr./km. (£7000 per mile), but no administration offices, running sheds, repair shops, or substation had to be provided. R. E. N.

368. *Six-motor Multiple-unit Trains for Montreal.* **K. MacLeod.** (El. Rly. J. 51. pp. 403–404, March 2, 1918.)—Some of the tramlines round Montreal are hilly, with gradients up to 13 per cent. They are equipped with two-car multiple-unit trains, which have Westinghouse controllers operated from storage batteries, each car having identical control with the exception of the rheostats. There are four motors on the motor-cars, and two on the front trucks of the trailers. A diagram shows the methods of connection: there are five distinct circuits in the control, viz., reset, forward and reversing, line switch, hand acceleration, and automatic acceleration. The method of accelerating consists in advancing and returning the main drum by differences of air pressure, and a double piston connected to the main drum through a rack and pinion. Whenever the line switch is in, air pressure is applied to a piston by means of a magnet valve and remains till the line switch releases. W. H. S.

369. *The Automatic Hydro-electric Generating Station of the Iowa Railway and Light Co.* **L. B. Bonnett.** (Gen. El. Rev. 20. pp. 918–923, Dec., 1917. Electrician, 80. 785–786, March 22, 1918. Abstract.)—An auxiliary station at Cedar Rapids, Iowa, comprising 8 vertical, 500-kv.a., 2-phase, 60-cycle, 2300-volt, 60-r.p.m. units working under 10 ft. head. Two 100-kw. induction-motor-driven exciters supply excitation, one only being large enough for 1·8 units. The station is 1000 yards from the 20,000-kw. steam station of the company and is connected by two one-phase concentric 600,000 circ.-mil. cables, 2300 volts. The units start and stop automatically by float switch control of the motor-operated gates, with the rise and fall of water in the forebay. They can be started and stopped by push-button from the steam station; for each unit is also a push-button which when opened shuts down the unit entirely and it cannot be automatically restarted until this button is reclosed. A motor-driven drum-type controller gives the correct sequence of operations, this motor being started in the first place by the float switch. The exciter induction motor is first run up, reaching speed in 8 secs. with full voltage and 6 times normal current. Next the motor-operated gate is opened enough to give the generator a free running speed of 70 cycles. The drum

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controller then stops until the generator speed reaches 55 cycles and is started again by a centrifugal switch on the generator shaft; after an interval of 2 secs. the generator is switched on to the bus-bars without field and in series with 20 per cent. reactance, the speed being then approximately 60 cycles. The controller moves on and the exciter increases the field of the generator, pulling it into synchronism and then raising it to full-load value, afterwards short-circuiting the reactance. Meantime the gate motor has come under the control of a contact-making ammeter, connected to a current transformer in the generator leads; this opens the gate until full-load current is flowing. The controller motor now stops in the full running position. Only 39 secs. elapse between the opening of the gate and the switching-in of the generator with reactance short-circuited and in 45 secs. the machine is on full load. An oscillogram is given showing the circuit conditions during these periods. The generators operate with fixed excitation, and if the water-level is too low to give full load, the highly excited generator takes care of the wattless kilovolt-amps. of the system. Thermostats are installed in the bearings, and if overheating occurs the machine will be shut down. Details are given of the satisfactory operation of the plant under emergency and breakdown conditions. The cost of the automatic control equipment is not greatly in excess of the ordinary hand-operated switchboard. The description is clearly illustrated, showing details of all the auto-control gear. W. E. W.

370. *Shipbuilding expedited by Electric Service.* **D. Elwell.** (El. World, 71. pp. 42–45, Jan. 5, 1918.)—The Staten Island Shipbuilding Co., N.Y., undertook contracts 18 months ago for a large tonnage of steel ships and required electricity for power and lighting, steam for heating, and compressed air for pneumatic tools. The company's engineers analysed a number of schemes for power production, which are discussed in detail, and decided to purchase energy from the Richmond Light and Railroad Co. and thereby save £1000 per annum; the existing steam boiler plant for heating was retained. Three-phase power at 220 volts is supplied from a local substation for the motor circuits; the lighting is at 110 volts, obtained by splitting one of the 8 phases with a 220/110 volt balancing coil. This arrangement saved the cost of separate high-voltage lighting transformers and separate lighting mains. Distribution throughout the yard is by armoured lead-covered cable laid direct in the ground. The installation includes three floating docks requiring 500 kw. each, three air compressors aggregating 1000 kw., and 800 kw. absorbed by cranes, winches, and a number of variable-speed machine tools. This 800 kw. is d.c. energy supplied from the power mains through motor-generators. W. E. W.

371. *Electric Power Supply at Buenos Aires.* (Engineering, 105. pp. 4–6, Jan. 4; 60–61, Jan. 18; 141–144, Feb. 8; 221–228, March 1, and pp. 301–304, March 22, 1918.)—Surveys briefly the history of the development of the undertaking of the Compania Italo Argentina de Electricidad and describes in detail, with plates, figures, etc., the power station at Calle Pedro Mendoza. The station is close to a deep-water wharf with several lines of railway and tramway between. Four fuel-oil tanks are placed in a pit 30 ft. deep along one end of the building; each has a capacity of 200 cub. m. The boiler-room, 74 ft. × 116 ft., has 8 water-tube boilers, by Francis Tosi, with superheaters and Green's economisers. The working pressure is 14 atmos. and the superheat temperature is 350° C. The heating surface of each boiler is 6028 sq. ft., and of each economiser 8445 sq. ft. Four more boilers, by Babcock and

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Wilcox, are to be installed, with two more oil tanks each of 22,950 cub. ft., and oil sprayers of the Kœrting-Tosi type. The turbine-room, 62 ft. × 116 ft., contains at present three 6250-kv.a., 3-phase, 7000-volt, 50-∿, 1500 revs. per min. turbo-generators; two were supplied by Brown-Boveri and one by Franco Tosi. Two more turbines by Brown-Boveri, each of 12,500 kv.a., are in course of erection; illustrations show the design of these machines in detail. The Tosi turbine is of the disc-and-drum type, with an output of 5000 kw.; 25 % overload can be carried by means of by-pass valves. For the larger turbines the steam pressure is to be 190 lbs. per sq. in. at the stop-valve, and superheated 240 deg. F. All steam connection pipes have expansion pieces on account of the high temperature. At the exhaust end of the turbine the disc construction is adopted, although the reaction principle of operation is used, on account of the high peripheral speed, about 600 ft. per sec. The blading of the intermediate section is on two drums independent of the main body of the rotor, making it possible to use lighter forgings than would otherwise have been required. The generators are all by Brown, Boveri and Co., the larger ones have the cylindrical rotor, introduced by C. E. L. Brown, built up of plates shrunk on the shaft. The main switchboard is of the cellular type and is arranged for 20 feeder cables. A 600-amp.-hour battery operates electric controls and is in reserve for excitation. Switchgear connections are described and circuit diagrams shown. There are five rotary converter substations distributing direct current on the 3-wire system at 445 to 480 volts across the outers. Instead of reserve batteries Diesel engines and generators are installed to provide for emergencies. There are in all 18 Franco Tosi 4-crank, 4-cycle, 500 revs. per min., 500-kw. Diesel engines, and 18 six-phase rotary converters, 8 of 1000 kw. and 5 of 500 kw. capacity. The fuel consumption of the engines is 185 gm. (0·408 lb.) per b.h.p.-hour. The Tres Sargentos substation is described, with diagrams of circuits. Alternating current is supplied from eight static substations with oil-cooled transformer with a total capacity of 1800 kv.a. at the end of 1916. There are nine high-tension feeders, three core, 70 mm.² section in each core, paper insulated for 10,000 volts, lead-covered and armoured with double steel band. W. N. Y. K.

372. *A 95,000-Kilowatt Plant.* (Power, 47. pp. 354–358, March 12, 1918.)—The generating plant at the North-west Station of the Commonwealth Edison Co., Chicago, has been extended by the installation of two turbo-generators (Nos. 5 and 6) of 80,000 kw., and one (No. 4) of 35,000 kw. capacity. No. 4 is an impulse turbine in a single casing coupled to a 25-∿, 3-phase, 1500 revs. per min. alternator. Nos. 5 and 6 each consist of a tandem-compound reaction turbine connected by a flexible coupling to a 60-∿, 3-phase, 1200 revs. per min. alternator. The high-pressure element, containing the governor and valve mechanism, is of standard single-flow pure reaction construction. Here the steam expands from 230 lbs. to 34 lbs. pressure, at the most economical load, and then passes by an overhead pipe to the low-pressure element, which is a combination of single and double construction, with reaction blading. The steam enters at the top near the centre, passes through a single stage of 20 rows of blades, and expands from 34 lbs. to about 8·5 lbs. absolute pressure. It is then divided and passes in opposite directions through two low-pressure stages of 16 rows of blades to two exhaust passages and two condensers each of 28,000 sq. ft. surface. There are 12,972 tubes 1 in. in diameter. Part of the surface, about 750 sq. ft., forms a primary heater for the feed water, and is placed at the entrance of

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the shell. A bi-rotor circulating pump direct-driven by a 600-h.p. induction motor supplies water to both condensers. A schedule is given of the entire plant and auxiliaries. W. N. Y. K.

373. *Appleton Steam and Water Plant.* **T. Wilson.** (Power, 46. pp. 444–449, Oct. 2, 1917.)—Describes the generating plant for light, power, and traction in Appleton, Wisconsin, and district. The plant is placed between the Fox River and the Government Canal; the difference of head between them averages 16 ft., and is used for power purposes. Originally two low-head water turbines, each with three pairs of wheels, were installed to drive two 500-kw. generators, one a.c. the other d.c., all on one shaft. A tandem-compound Corliss engine at the other end of the shaft acted as stand-by for use when the canal froze or when water was low. Magnetic shaft couplings were used. Later two 1250-kw. turbo-alternators, using exhaust from the Corliss engines and steam from four Stirling boilers, were installed. Then the building was extended and one set of water-wheels removed to put down two 650-kv.a. single runner, vertical shaft water-turbines and two 5000-kw. steam turbo-generators, supplying 3-phase 60-∿ current at 4000 volts and 3600 revs. per min. Four water-tube boilers are erected and space is provided to duplicate the plant. Auxiliaries are electric-driven; the boilers are equipped with economisers, forced and induced draught, and modern coal- and ash-handling machinery. Plan, elevation, and views are given. Coal is delivered by water or rail. A large store, 270 ft. × 140 ft., will hold about 35,000 tons, and is served by a travelling gantry crane. The condenser has no atmospheric relief valve; in case of excessive steam pressure a special balanced valve shuts off the steam supply to the turbine. The steam-driven generators supply the main bus-bars in two sections; the water units supply an auxiliary bus-bar which may be connected to either section of the main buses. For transmission the voltage is stepped up to 66,000 and 88,000 volts in apparatus erected on a steel structure outside the station. W. N. Y. K.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

374. *Return Circuits for Traction Systems.* **F. Guery.** (Soc. Int. Élect., Bull. 8. pp. 27–44, Feb., 1918.)—This is a study of the existing French regulations with regard to the so-called "kilometric volt," *i.e.* the fall of one volt per km. in the return conductors. The author suggests that certain changes in this regulation are desirable, and proposes that each company should keep records, drawn up on the basis of his suggestions, whereby it should be possible for the authorities to satisfy themselves that there was no risk from stray currents. This would obviate the necessity of penalising undertakings that were causing no damage. W. H. S.

375. *Geared Locomotives for Shunting.* (Engineering, 125. p. 108, Feb. 1, 1918.)—Geared locomotives are found to be better than the connecting-rod type where loads are heavy, distances short, and permanent way rough or of light construction; they are particularly suitable for shunting service. The whole weight of engine and tender is adhesive, and its wide distribution reduces track stresses. Driving bogies are used, so that the engine can pass any curve which a goods wagon can negotiate, without the injury to track

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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and risk of derailment involved by ordinary locomotives. Other advantages claimed are lower first cost, lower maintenance costs, and lower working expenses where speeds are low. Their quick acceleration is a valuable feature. Acceleration tests with a double bogie or 8-wheeled geared engine and a 6-coupled (0–6–0) engine showed the former to be quicker by 28 % in 100 ft.; 22½ % in 200 ft.; 18½ % in 300 ft.; 14½ % in 400 ft.; and 12½ % in 500 ft. run. The geared engine reached 12 miles/hr. in 22 % less time than the rod-connected engine. The geared engine was much more accurate in stopping at marked places. R. E. N.

376. *Return of Current by the Rails.* **E. Brylinski and G. Girousse.** (Soc. Int. Élect., Bull. 7. pp. 261–292; Disc., 292–305, Nov., 1917.)—A lengthy article concerning the return of current by the rails in d.c. traction systems with the object of determining the manner in which the current so returned is influenced by the resistance of the rails, their insulation resistance, the resistance of the soil, the voltage drop along the rails, and the current strength at different points of the track. Three separate cases form the subject of the calculations: (1) The potential of the mid-point of the track is assumed to be zero, *i.e.* all the load is taken off at the end of the track and the current is supposed to leave the track along its more distant half and return to the track along its nearer half, no current returning to the station through the earth; (2) all the load is taken off at the end of the track and the potential of the remote end of the track is assumed to be zero, *i.e.* the current is supposed to leave the track along its whole length, all the current returning to the station through the earth; (3) the load is supposed to be taken off uniformly along the track. In case (1) the drop in the rails per unit length increases as the distance from the mid-point is increased in either direction. In case (2) the drop in the rails per unit length increases continually as the distance from the station is increased and the danger of electrolytic action may be great at remote sections although the mean drop per unit length may be within prescribed limits. On the assumption that the loss of current from the rails at any point at distance x from the station is proportional to the potential of the earth at that point and inversely proportional to the resistivity of the soil, it is shown that $dI/dx = U'/(K\rho_s)$, where I is the current in the rail, U' the potential of the earth near the point x, ρ_s the resistivity of the soil and K a coefficient depending on the shape of the rails. The value of K is calculated on the assumption that the rails have a cylindrical base of radius r_0 and is given by $K = (1/\pi) \log (r/r_0)$, up to distances r from the rail. If r is considerably greater than r_0, the value of K may be taken as about 2·5. If U is the potential of the rail at distance x from the station,

$$U/U' = (\gamma\rho' + 1)/(\gamma\rho') = m,$$

where γ is the conductance of the leakage paths from the rail to the earth and $\rho' = K\rho_s$. Numerical computations lead to the conclusion that the current returning by the earth is highly dependent on the value of γ, so much so, that it seems advisable to tar the under sides of the rails when laying them in order to improve their insulation. One of the grave objections to the statutory limit of voltage drop in the rails consists in the above-mentioned divergence between the max. and average drops per unit length, and another consists in the fact that it is often impossible to keep within the given limit without increasing the magnitude of the current that returns through the earth. The calculations lead to the conclusion that in case (3) the voltage drop to the end of the line may be expected to be

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reduced to about 40 to 50 % of its value with the load concentrated at the end of the line, and the current returning by the earth to about 70 % of the value in the concentrated loading. In the *discussion*, a number of interesting cases of electrolytic action are mentioned and the regulations limiting the voltage drop in the rails with the object of diminishing electrolytic action are criticised. A. J. M.

377. *Early Experimental Study of Rail Wear.* **R. C. Cram.** (El. Rly. J. 51. pp. 168–171, Jan. 26, 1918.)—Probably the earliest experiments to determine rail wear were made on the Nassau Electric Railroad (Brooklyn) about 22 years ago. Cast-iron boxes were attached to the rails to make possible periodical determination of wear. These boxes were recently discovered and it was found possible to add appreciably to the results published by A. J. Moxham in 1898. The wear in the head area now amounts to 27–29 %. The max. vertical wear $\frac{1}{4}$ in. back from the original gauge line has been about $\frac{1}{32}$ in. per year on old Bessemer steel rails with less than 0·6 % carbon. There have been nearly 10 million wheel passages over each rail, assuming 4 minutes' headway of 8-wheel cars for 20 hrs. per diem. Electrically welded joints of the "bar-weld" type were installed by the Lorain Steel Co. in 1898 and most of these joints are still in satisfactory service.

The original wear tests compared soft and hard carbon-steel rails with 0·28 % and 0·59 % carbon (other ingredients the same in both cases), and a special hard and ductile steel with 0·57 % C, low phosphorus and high Si and Mn. Analyses and test data are given in the original, together with extracts from Moxham's paper, which are still applicable. Moxham concluded that the joint problem was the most serious, and that (in 1898) even the cheapest rails would last longer than the joints would permit the rails to be kept in the track. Measurements after 22 years' service show that the actual wear on hard and soft rails agrees fairly well with the original estimate, but that the rate of wear on the "hard and ductile" rail (formerly very low) has increased until it is now probably as great as that on the hard rail. The conclusions now reached are, that there is still some question as to the effect of chemical composition on rail wear, but the high carbon-content incorporated in present standard analyses should be maintained. Joint constructions have improved so much that reasonably high expenditure on good quality rail steel is now justified.

The original measurements were based on overall height and the rail bases are now so much corroded that complete comparison with the original data is impracticable. R. E. N.

ELECTRIC LAMPS AND LIGHTING.

378. *Polar Curves of Symmetrical Lamps.* **J. Ondracek.** (Elektrot. u. Maschinenbau, 36. pp. 77–81, Feb. 17, 1918.)—Proposes the use of Fourier series for the determination of the polar curve of a light-source radiating symmetrically about its axis. The intensity is measured in, say, 5 different directions, viz. at 0°, 30°, 45°, 60°, and 90° with the horizontal, and from these values the first five coefficients of the Fourier series are calculated, and hence the mean spherical or mean hemispherical candle-power deduced.

J. W. T. W.

379. *Filaments of Crystal Wire.* **O. Ely.** (Zeits. Vereines Deutsch. Ing. 62. pp. 15–20, Jan. 12, 1918.)—A general article on metal filaments with

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special reference to the tungsten wires of J. Pintsch [see Abs. 846 (1917)]. The wires proved mechanically strong after 1200 hours' burning, and there was no black deposit on the inside of the bulbs. H. B.

380. *Glow-lamp for Projection Purposes.* **L. C. Porter.** (Gen. El. Rev. 20. pp. 979–988, Dec., 1917.)—Arcs have been preferred to glow-lamps for kinematograph work hitherto on account of (1) the high intrinsic brilliancy of the arc crater, (2) the condensers using a solid angle of light of about 82° which is adapted to the light distribution of the arc, but less so to that of filaments, and (3) the crater of the arc being a homogeneous source, giving even illumination, whereas the projection of images of filaments is apt to produce streakiness. These obstacles have been overcome by the design of a special lamp and condenser adapted thereto. The lamp takes 750 watts and operates at 30 amps. and 25 volts. The filament consists of four helices in one plane, being designed with a view to the fact that the condenser will pick up light from a 0·4 in. square. The condenser is of the "semaphore" type, consisting of one piece made in steps or corrugations, and will intercept a solid angle of 75° of light; this is virtually doubled by means of a spherical mirror behind the filament which is at the radius of curvature of the mirror.

The condenser is 4 in. in diam., with conjugate foci 2½ and 6½ in., the filament and objective being placed at these respective distances. The filament is run near its melting-point in order to obtain max. brilliancy, and has then a life of 100 hours. A table is presented showing the economy in consumption of energy as compared with various arcs. The lamp will replace any a.c. arc on the market, and d.c. arcs up to 40 amps., and will project a picture 12 ft. wide on a white plaster screen, or 16 ft. wide on screens of metal, fibre, or glass. J. S. D.

381. *Street Lighting with Modern Electric Illuminants.* **S. L. E. Rose and H. E. Butler.** (Gen. El. Rev. 20. pp. 945–968, Dec., 1917.)—The paper contains an exhaustive summary of the results obtained in street lighting by the chief forms of units employing glow-lamps and arcs. Diagrams are exhibited showing the advances in the efficiency of glow and arc lamps during the periods 1900–1916 and 1880–1916 respectively. Illustrations, polar curves, and diagrams indicating the distribution of illumination on the street surface for a variety of lighting units are presented. J. S. D.

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TELEGRAPHY AND TELEPHONY.

382. *Application of Austin-Cohen Formula to Problems in Radio-telegraphy.* **L. Bouthillon.** (Rev. Gén. d'Él. 3. pp. 419–424, March 23, 1918.)—The Austin-Cohen formula for the value of the current in the antenna at a receiving station is considered with reference to the determination of the characteristics of transmitting and receiving stations, the calculation of the range of the transmitting station, the optimum wave-length, and the efficiency.

Expressions are obtained for the optimum wave-length and the efficiency, corresponding to conditions which obtain in practice. A curve is given showing the relation between the optimum wave-length and the range.

An abac is given embodying the optimum wave-length, range, current in antenna at receiving station, and a factor D, where—

$$D = \lambda(R_\rho + S_\rho\omega^3)(1 + \delta_e/\delta_\rho)^{1/2}/l_e l_\rho I_{e\,\mathrm{eff}}.$$

Here $I_{e\,\mathrm{eff}}$ = current at base of transmitting antenna; l_e, l_ρ = effective heights of transmitting and receiving antennæ; δ_e = decrement of emitted waves; δ_ρ = decrement of waves in receiving system; R_ρ = resistance of receiving antenna; $S_\rho\omega^3$ = radiation factor of receiving antenna; λ = optimum wave-length. By means of the abac, if any three of the above quantities are given the fourth can be found. N. W. M.

383. *Telephone Receivers and Radio-telegraphy.* **H. O. Taylor.** (Inst. Radio Eng., Proc. 6. pp. 37–58, Feb., 1918.)—The first part of the paper is a recapitulation of Kenelly's work on the motional impedance circle of the telephone receiver [Abs. 1257 (1912), 1715A (1915), and 241A and 490 (1917)]. The author points out that it has been possible to use the motional-impedance circle to determine the motional constants, and that from the experience so gained it is now possible to estimate them from measurements of the dimensions and mass of the diaphragm. From these constants the natural frequency and the logarithmic decrement of the receiver can be found. On this basis the effect of the thickness and radius of the diaphragm upon the natural frequency and breadth of tuning are studied. The results may be summarised as follows :—

By halving the—	The natural tone is—	The breadth of tuning is—
Thickness	lowered one octave	doubled
Diameter	raised two octaves	unaffected.

These statements are, however, only approximations, as they assume a constant mechanical resistance for varying diaphragm thickness and neglect the membraneous quality of thin diaphragms and their concave shape due to the magnet pull.

The conditions affecting sensitiveness are discussed generally and some notes on audibility are given, including a table of audibility currents for the four receivers studied by Kenelly and Affel [Abs. 490 (1917)]. A comparison of five classes of receiver construction concludes the paper. A bibliography of receiver investigations is appended. W. H. G.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

JUNE 1918.

PRIME MOVERS.

STEAM PLANT.

384. 8000-*kw. Compound de Laval Steam Turbine.* (Engineering, 105. p. 514, May 10, 1918.)—Four plates show views, external and sectional, of a 8000-kw. steam turbine and generator at Gothenburg. Current is generated at 6000 volts, 8-phase, 25 ∿, 1500 revs. per min. Overload of 20 % can be carried continuously. The turbine is of the compartment compounded-impulse type with a two-row velocity-compounded stage at the high-pressure end. The casing is of cast iron with nozzle boxes outside. The intermediate pressure end is supported by a sliding foot on an independent bedplate. The back end rests on two cantilever extensions of the generator bedplate The diaphragms, slightly dished, are of cast iron made in halves. Carbon glands pack the shaft, with supplementary packings to prevent full steam pressure reaching the packing. The wheels are of forged steel heat-treated and mounted on removable seats. The condensing plant is shown.

W. N. Y. K.

385. *Substitution of Oil for Coal.* (El. World, 71. pp. 711–714, April 6, 1918.)—Relates instances in New England of the many advantages obtained by using oil in place of coal for boiler fuel. Plants of nearly 100,000 h.p. aggregate capacity are working on oil fuel, though the lack of normal shipping facilities hinders the developments expected in the times of peace. Oil is also rapidly coming into favour as fuel for heating office buildings, etc. The oil used is the so-called "topped" oil from Mexican or other southern wells, with calorific value of from 18,800 to 18,500 B.Th.U. per lb.; 150 galls. of this is equivalent to about 1 ton of coal. It does not emit inflammable vapour below 150° F., and burns clean. Providence, R.I., and Boston, Mass., are the two principal oil ports. Distribution is made by automobile trucks and tank cars. The price per gall. has varied from 2·5 cents in 1915 to 6 or 7 cents maximum, and the present average is 4 to 5 cents. A continuous supply can be relied on. As compared with coal, oil gives higher efficiency at the boiler, more equal distribution of heat, reduction in costs of

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handling, equipment and repairs, and less cleaning; also charges for banked fires are eliminated, a smaller staff is required (one fireman will take charge of 10 to 15 boilers), while an increased boiler capacity of from 10 to 75 %, according to conditions is obtained. The same chimney will suffice for 40 % more power. The annexed table gives the test results obtained during one week on two 140-h.p. horizontal return-tubular boilers. The advantages gained in the case of other plants are detailed, namely, the Jenckes Spinning Co., Pawtucket; the Tamarack Co's. No. 2 mill power plant; the Almy Water-tube Boiler Works; and the Lauderdale plant, in Providence.

	Oil.	Coal.
Hours generating steam	125	126
Average steam pressure, lbs.	108 to 127	89 to 127
„ feed-water temp., °F.	84 to 150	81 to 151
CO_2 in flue gas, %	14	not taken
Flue gas temp., °F.	449	not taken
Moisture in steam, %	1·75	1·75
Calorific value, B.Th.U. per lb.	18,700	14,600
Total boiler h.p.	300	300
Boiler h.p. developed	285	202
Feed to boilers, lbs.	1,089,586	794,742
Evaporation from and at 212° F. (lbs. of water per lb. fuel)	15·55	10·31
Boiler efficiency, %	80	68

W. N. Y. K.

386. *The Use of Pulverised Coal.* H. R. Collins. (Am. Inst. Mining Eng., Bull. No. 126. pp. 955–961, April, 1918.)—Describes the process of pulverising, methods of supplying it to boiler furnaces and the advantages of using it. The most suitable grades of coal for kilns, boilers and metallurgical furnaces contain about 25 % volatile, 50 % fixed carbon, ash 8 % or less, and sulphur 2 % or less. Coals with 25 % ash and 5 % sulphur have been used without trouble. Storage bins should be dust-tight and have steep sides. Drying the coal facilitates pulverising, the obtaining of high and uniform temperatures, and handling. Moisture content should be less than 1 %, except in lignites; these latter can be easily handled with 5 to 8 % moisture. Grinding should be fine enough for 95 % to pass through a 100-mesh, and 70 % through a 300-mesh sieve. On the basis of 200 tons per day coal with 7·5 % moisture the cost of pulverising will be between 30 and 40 cents per ton, not including overhead charges, interest, and depreciation. To minimise danger from ignition of a combustible mixture of dust and air the conveying should not be done by air currents and leakages should be stopped. A good mixing projector should be designed to receive the fuel in regulated quantities, break up the fuel, and distribute it with the correct proportion of air at the proper velocity. Four types of burner are described.

W. N. Y. K.

387. *Stoker Capacity and Boiler Forcing.* J. T. Foster. (Power, 47. pp. 576–578, April 23, 1918.)—The fact that the efficiency of boiler working depends as much on the grate area as on heating surface has not been sufficiently realised. The input of B.Th.U. is the governing factor in boiler output and, since heat input is dependent on grate surface, calculations

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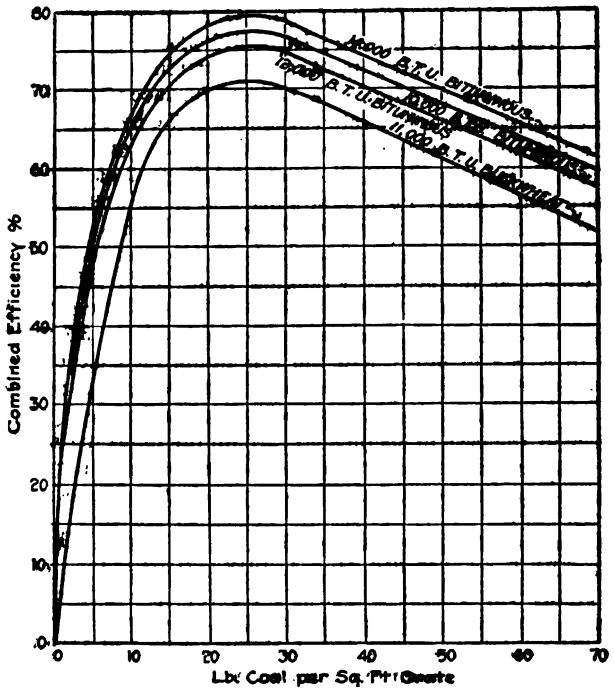
should be based on grate area. Curves plotted of combined efficiency against lbs. of coal burned per sq. ft. grate area show a characteristic curve of definite form independent of the nature of the fuel and the size of the boiler. Examples of these curves are shown [see Fig.]. Charts of



curves are given showing efficiencies plotted against lbs. of coal per sq. ft. grate per hour, and boiler h.p. per sq. ft. grate, for various sizes of boiler; also the savings represented under differing conditions are shown. Examples of the method of using the charts are worked out. W. N. Y. K.

GAS, OIL AND WATER ENGINES.

388. *Suggestions for the Safe Operation of Gasoline Engines in Mines.* **R. H. Kudlich** and **E. Higgins.** (Bureau of Mines, Techn. Paper, 174. [19 pp.] Washington, 1917.)

389. *Traction on Bad Roads or Land.* **L. A. Legros.** (Inst. Mech. Eng., J. No. 8. pp. 55–151; Disc., 152–158, March, and No. 4. pp. 159–194, April, 1918. Engineering, 105. pp. 86–88, 89 and 90, Jan. 25; 118–120, Feb. 1; 144–148, Feb. 8; 185–188, Feb. 15; 213–217, Feb. 22, and pp. 239–242, March 1, 1918.)—This monograph should be referred to for the numerous photographs and the tables of data relating to the various vehicles. The two main classes of tractor, namely, those having more than two driven wheels, and those driving through chain-tracks, are fully dealt with. For the transport of goods, tractors of the first type are considered to have great advantages over the two-wheel driven tractor. A remarkable feature about the chain-track tractors is the small amount of power lost in compressing soft marshy land under the feet of the track chains. L. H. W.

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PROPERTIES OF ENGINEERING MATERIALS.

390. *Acid-resisting Iron-Silicon Alloys.* **O. L. Kowalke.** (Am. Electrochem. Soc., Trans. 31. pp. 205–210; Disc., 210–212, 1917.)—Electrolytic iron and ferro-silicon were fused in Acheson graphite crucibles, lined with magnesia, the crucible standing in a resistor furnace; the alloys were cast in moulds of the same graphite into specimens of 7·6 by 3·2 by 0·15 cm. The alloys were not stirred while in the furnace; they ranged in silicon from 1·2 up to 19·5 %, the low-silicon alloys made soft, good castings; above 3·5% Si they were brittle, above 7·5 % so strained that some would break into small pieces in the mould or fly apart with violence (above 11 % Si). Corrosion tests were made in acids (sulphuric, hydrochloric, nitric, acetic, citric) of 10 % by weight at temperatures ranging from 20 to 25° C. The loss of weight was determined at intervals, the series of tests lasting 29 days. In sulphuric and hydrochloric acids the loss was greatest for 3·7 % and smallest for 16 or 18 % Si; in nitric acid the loss diminished steadily until the Si percentage was 16, increasing afterwards; in acetic and citric acids the loss increased up to 5 or 8·8 % Si, decreased then, and rose again with more than 16 % Si in the case of acetic acid. In all the cases the minimum losses amounted only to fractions of 1 per cent. The obvious limitations of the experiments were pointed out by **C. F. Burgess** in the *discussion*. H. B.

391. *Corrosion of Surface Condensers by Sea-water.* **G. Costesèque.** (Rev. Gén. d'El. 3. pp. 647–650, May 4, 1918.)—The author of this note is manager of the Cap Pinède station of the Compagnie d'Électricité de Marseille, and he gives here the results of his experiences with the condenser plant at this works, which possesses four turbo-generators of 1800 kw. and three of 6000 kw. All the condensers suffered from corrosion—which was very severe in particular instances. In the case of the smaller units, seven plates of zinc measuring 800 × 150 × 25 mm. in thickness were fixed upon each of the tube-plates of the condensers, the total active surface of zinc being about 10,800 cm.², or 81 cm.² per sq. m. of condensing surface. In the case of the larger units, zinc plates were also found to be useful in preventing corrosion, except in the case of one condenser provided with brass tubes of German origin, containing 70 % copper, and tinned externally. No variation of the form or position of the zinc plates was satisfactory in preventing trouble with this condenser—and after trying insulation which was also ineffective, it had to be put out of service and the German tubes replaced by English ones, testing 70 % copper, 29 % zinc, and 1 % tin. These tubes were not tinned but with the adoption of the same precautions as in the other sets, they have yielded quite satisfactory results. In order still further to guard against corrosion, the plant is now equipped with means for passing feeble counter-currents of electricity between the plates of zinc and the brass tubes, although at the time this was planned the Cumberland process was unknown to the author. In conclusion, the author expresses the opinion that the corrosion of surface-condenser tubes by sea-water is due to electrolytic action, and that tubes of perfectly similar chemical composition may behave differently in the same condenser at different times. The physical and internal molecular structure of the metal of the tube has some influence on the resistance of the brass to corrosion, and when corrosion is occurring and cannot be checked by the means described above, complete change of all

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the tubes of the condenser, and the use of tubes of other manufacture, will sometimes prove the most effective and cheapest remedy. J. B. C. K.

392. *British Chemical Standards—Iron and Steel.* (Engineering, 105. pp. 374–375, April 5, 1918.)—Some two years ago Messrs. Ridsdale and Co. of Middlesbrough placed on the market six samples of steel standardised by a number of co-operating chemists. The above paper describes a meeting convened at Newcastle-on-Tyne on Feb. 22nd, with a view to elaborating the scheme by inviting other chemists to co-operate in the issuing of further standards. It is hoped that the No. 5 Committee of the Iron and Steel Institute will ultimately take over the work. The scheme is to supply standardised samples of iron and steel at prices calculated as being just sufficient to cover the cost. F. C. A. H. L.

393. *"Carbo-coal."* **C. T. Malcolmson.** (Am. Inst. Mining Eng., Bull. No. 137. pp. 971–977, May, 1918.)—The low-temperature distillation of coal has interested investigators for many years, and an elaborate series of experiments which have been carried out by C. H. Smith at Irvington, N.J., have resulted in the development upon a commercial scale of a process which produces (1) a fuel, called "Carbo-coal," which for convenience of handling is prepared in briquette form; (2) a yield of tar more than double that obtained in the ordinary by-product coking process; (3) ammonium sulphate in excess of that normally recovered in the ordinary by-product coking process; (4) gas in amount approximately of 9000 cub. ft. per ton of coal carbonised, at present used in the process.

The essential features of the Smith process are the two distillations carried on at different temperatures. The raw coal, after being crushed, is distilled at a relatively low temperature, 850° to 900° F., and the volatile contents are thereby reduced to the desired point. The result of this first distillation is a large yield of gas and tar, and a product rich in carbon, termed *"semi-carbo-coal."* The semi-carbo-coal is next mixed with a certain proportion of pitch (obtained from the tar produced in the process) and this mixture is briquetted. The briquettes are then subjected to an additional distillation at a higher temperature, approximately 1800° F., resulting in the production of carbo-coal, the recovery of additional tar and gas, and a substantial yield of ammonium sulphate. The characteristic feature of the primary distillation is, that it is continuous and that the coal is constantly agitated and mixed during the entire operation. This is accomplished by a twin set of paddles, which also advance the charge through the retort. The period of distillation is 1 to 2 hrs., and the continuous retort has a carbonising capacity of one ton of coal per hour. In the subsequent distillation of the briquettes, all evidence of the pitch as a separate ingredient disappears. There is a marked shrinkage in volume, with a corresponding increase in density, but no distortion in shape. This distillation requires 4 to 5 hrs., and is performed in an inclined, self-charging, and self-discharging bench. The final product represents more than 72 % of the weight of the raw coal, the exact percentage depending upon the volatile contents of the latter.

Carbo-coal is dense, dustless, clean, uniform in size and quality, and can be readily handled and transported long distances without disintegration. It is greyish black in colour, slightly resembling coke, but its density more nearly approaches that of anthracite coal. It is manufactured in briquette form, and can be made in any size, from 1 oz. to 5 oz. The larger sizes are better suited to locomotive purposes, and the smaller sizes for domestic use. It has been found

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particularly suitable for the following purposes: (1) Marine and locomotive service, where limited grate-area and restricted boiler capacity demand efficient fuel, also where smoke is objectionable or dangerous, as in the case of ships in time of war. (2) Stationary boilers, where smoke pollution of the air is offensive and dangerous to health. (3) Domestic uses, including furnaces, stoves, ranges, and open grates, where cleanliness is a desirable factor. (4) Kilns, drying and roasting ovens, and all purposes where an intense and uniform heat is desired. (5) Metallurgical furnaces, as a substitute for coke. (6) Gas-producers.

Steam-raising Tests.—Carbo-coal has been tested by various American railways and by the U.S. Navy. These tests have demonstrated that the fuel is smokeless; that it will evaporate from 8·5 lbs. of water at a combustion rate of 100 lbs. per sq. ft. of grate surface per hr. from and at 212° F. per lb. of fuel fired; and that it requires no greater draught than bituminous coal. A max. combustion rate of 166 lbs. per sq. ft. of grate surface per hour has been reached for a short period.

Domestic Trials.—Carbo-coal has been subjected to practical tests in household use for over a year. It fulfils all requirements of a domestic fuel—and can be burned satisfactorily without change of furnace or grates, responding readily to changes in draught. The uniformity of combustion, absence of fumes, even distribution of ash, and absence of clinker as compared with the coal from which it is made, are additional characteristics in its favour.

Analysis.—The amount of ash and sulphur in the carbo-coal depends upon the characteristics of the coal from which it is made. The summarised proximate analyses of carbo-coal, manufactured from 25 different coals at the Irvington plant, are shown below:—

	From Run of Mine Coal. %	From Washed Coal. %
Moisture	1·00 to 3·00	1·00 to 3·00
Volatile matter	0·75 to 3·50	0·75 to 3·50
Fixed carbon	82·00 to 88·00	85·00 to 90·00
Ash	8·50 to 12·00	7·00 to 10·00
Sulphur	0·5 to 1·50	0·6 to 1·50

Yield of Tar.—The total yield of tar by the carbo-coal process is large. Coal containing 35 % volatile combustible produces more than 30 galls. of water-free tar per short ton. The tar obtained in the primary distillation of the coal has a sp. gr. of 1·00 to 1·06; it contains a large percentage of light solvent oils, tar acids, and cresols, but very little carbolic acid, and no napthalene or anthracene. The free-carbon content of this tar is low. The light oils contain appreciable quantities of naphthenes, pentane, hexane hexahydro-benzenes, and also hydrocarbons of the paraffin series, which make these oils valuable as a substitute for gasoline.

During the low-temperature distillation period, 20 to 28 galls. of tar, including the light oil obtained from the stripping of the gas, are recovered, the exact amount depending upon the volatile content of the coal. In the second, or high-temperature distillation, 5 to 6 galls. of tar are added to the above yield. This tar is heavier than that obtained from the first distillation and is similar to coke-oven tar. J. B. C. K.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

394. *Electrolytic Pickling of Steel.* **M. de K. Thompson** and **O. L. Mahlman.** (Am. Electrochem. Soc., Trans. 31. pp. 181–186; Disc., 186–189, 1917.)—Two similar mild steel plates, covered with equal amounts of scale, were pickled by the ordinary and electrolytic methods until their appearance showed that pickling was complete. The pickling baths were then concentrated until all solid matter which had dropped off was dissolved, and were then analysed for iron. The amounts of iron dissolved in the two processes formed the basis of comparison. The chemical pickling consisted in immersing in a boiling sulphuric acid solution of about 5 % strength until the surface was cleaned of scale. In the electrolytic pickling the iron plate formed the kathode between two lead anodes in sulphuric acid of density 1·2; the temperature was about 60° C. The results, both as regards efficiency and the saving in expense, were greatly in favour of the electrochemical method.

The extent to which fused magnetite is reduced in sulphuric acid solution of density 1·2 under different conditions of temperature and current density was also measured. The results show that the reduction is most efficient at about 50° C. and with a current density of 50 amps. per sq. ft. [See also Abs. 170 (1918).] T. S. P.

395. *Electric Furnace for Steel Castings.* **R. F. Flinterman.** (Am. Electrochem. Soc., Trans. 31. pp. 69–77; Disc., 77–80, 1917. Met. and Chem. Eng. 16. pp. 574–577, May 15, 1917. Mech. Eng. 39. pp. 413–415, June 8, 1917. Abstract.)—The Michigan Steel Castings Co. of Detroit uses electric furnaces for making small castings of automobile trucks, etc., the castings ranging in weight from ½ lb. to 300 lbs. and more; average about 20 lbs. These had been made first in crucibles and then in side-blown Tropenas converters. In the winter of 1915/16 two tilting Héroult furnaces (one of 6 tons, the other of 3 tons) were installed and have been run continuously since. The electric steel is not free from blowholes, but superior mainly because it is very low in oxides, sulphur, and slag. Noteworthy is also that long, thin sections do not develop shrink cracks now, which was a great trouble before; the quality of the steel can be relied upon. The lining was originally basic; owing to the scarcity of magnesite acid bottoms and linings were adopted, and there is less slag trouble then. A reverse-duplexing process is proposed: part of the metal is melted and refined in a basic furnace, sulphur and phosphorus being eliminated; the charge is then added to another part of the steel, meanwhile fused in an acid furnace, where the deoxidation is completed. With that process the raw material could be high in sulphur and phosphorus (screw machine turnings), and the basic furnace be run at lower temperature. H. B.

396. *Rennerfelt Electric Furnace Operation.* **C. H. vom Baur.** (Am. Electrochem. Soc., Trans. 31. pp. 87–91; Disc., 91–96, 1917.)—The hearth is now [see Abs. 580 (1917)] made circular, with one set of electrodes, or oval-shaped with two sets, and the side electrodes are adjustable in a vertical plane allowing them to dip towards the bath; the instantaneously available heat has thus been largely increased, and the furnace is spared. With the flame in the centre the heat distribution is uniform at the slag line; the arc is formed,

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as in the Stassano furnace, between the electrodes above the slag; as the charge melts the electrodes are lowered, so that the flame is 6 or 7·5 cm. above the bath; the heating of the slag is thus intensified whilst the roof and sides are not exposed to the greatest heat. The flame generally has a diam. of 20 or 25 cm. and then spreads out into a mushroom; with an oval hearth, the flame spreads over the entire bath. There are no details of the electrode mechanism nor any constructive details, but it is mentioned that the joint between the graphite electrode and its cap is simply conical, that is, the cap ends in a cone of 50° which the hollow end of the carbon fits directly, there being no shoulder to the edge of the carbon; these carbons are said to be mechanically stronger than those provided with a shoulder. The *discussion* concerned the electrode breakages and the power consumption; the figure given for bronze journal bearing, 160 kw.-hrs. per net ton, was questioned. H. B.

397. *Rubber Vulcanisation by Selenium.* **C. R. Boggs.** (Industr. Eng. Chem., J. 10. 2. pp. 117–118, Feb., 1918. Chem. News, 117. pp. 199–200, May 24, 1918.)—Experiments have been made since 1918 by the Simplex Wire and Cable Co., Boston, Mass., chiefly with the black crystalline modification of selenium which melts at 217° C. and into which the amorphous modifications pass between 100° and 150° C. Using an amount of Se (black modification, also the amorphous) equivalent to the S of ordinary vulcanisation and heating to 150° C. for a couple of hours, a vulcanised product was obtained which remained good for four years, though it was not so strong mechanically as the ordinary vulcanised rubber. Prolonged heating did not improve matters; rubber treated with twice as much Se deteriorated. By the use of organic accelerators (not specified) and a temperature of 135° C. for twice the period sulphur would require, rubbers of normal tensile strength and elongation were produced; they are softer and of lower dielectric strength than sulphur-rubbers, but have aged well. The chemical analysis is difficult because Se is hardly soluble in the usual solvents, acetone, chloroform, and carbon disulphide. The remarkable points are that the vulcanisation takes place at a temperature far below the melting-point of Se, and that the selenium-rubber does not deteriorate, although Se is sensitive to light. H. B.

398. *Electrolytic Metering Can.* (Electrician, 81. pp. 88–89, May 17, 1918.)—This instrument is due to E. O. Schweitzer (Chicago) and is designed to replace d.c. watt-hour meters in the installations of small consumers. This eliminates the cost of meter readings and of making out small bills. A short cylindrical copper anode is made part of the main circuit. At the same time, a small fraction of the main current is shunted from the anode through a solution of copper sulphate to a copper kathode which also forms the containing "can." When the anode is completely dissolved the main circuit is interrupted. There are no mechanical parts to be adjusted and nothing to be weighed or balanced. The resistance ratios are adjusted so that resistance variations in the electrolytic cell are of very slight importance. The device opens the supply circuit directly the consumer has used a specified amount of current for which he has paid.

The shunt current used for electrolysis is one-thousandth of the main current. When the anode is eaten away, current continues to pass for a short time between the leads which formerly led into its ends. The column of liquid thus placed in circuit causes a certain pressure drop and, in addition, there is heating which melts a low-temperature solder and releases a copper cylinder that definitely breaks the main circuit above the level of the electro-

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lyte. The interval between the first warning flicker and total cut-off is generally some minutes and is capable of adjustment. The principal source of error is variation in electrolytic resistance in the cell; this resistance varies with time, temperature, and load. Under average service conditions an accuracy of ± 2 % is easily obtained. The d.c. watt-hour meter is rather more accurate than the electrolytic type on light loads but the internal energy loss of the former (*e.g.* 5 watts in the pressure coil of a Thomson C 6 watt-hour meter) is constant and is a serious factor where very small useful loads are concerned. Small residence consumers purchase electric service as such, rather than electrical energy in any considerable quantity. The meter "can" puts the supply of electricity on a merchandise basis in that "cans" for an average quarter's or year's consumption may be bought at proportionate prices and in a single transaction. A full-size one may be paid for by 12 monthly instalments. R. E. N.

399. *Loop Tests for Fault Locating.* **G. W. Stubbings.** (Electrician, 81. pp. 40–41, May 17, 1918.)—Localisation tests are generally fall of potential tests or loop tests. Capacity tests for discontinuity are rarely required. The fall of potential test is simple and convenient, but unless the fault resistance is constant it is necessary to maintain constant test current by means of an ammeter and adjustable resistance. Resistance variations cause no trouble in loop tests, which are therefore preferable where faults of varying resistance are concerned. In loop tests the fault may be in the galvanometer or current circuit. It is more convenient to have the fault in the current circuit, principally because the testing current can then be obtained from the live mains through a small bank of lamps, instead of from a special testing battery.

The author gives instructions and formulæ for loop tests to meet the following cases:—(*a*) Resistance of return cable unknown; method explained which does not necessitate knowledge of the equivalent length of the return cable. (*b*) Current available at each end of the faulty cable. (*c*) Current available at one end only; method given by which all observations may be made from one testing station. (*d*) One return wire available; current at one end only; fault of high resistance. (*e*) Same as (*d*), except that fault resistance is low, necessitating a second test using a longer loop. (*f*) Test for concentric cables with short circuit and an earth on the outer conductor. Though not quite so simple as fall of potential methods, loop tests yield higher accuracy. R. E. N.

400. *Influence of Daily Variations in Frequency on the Accuracy of Induction Meters.* **A. Durand.** (Soc. Int. Élect., Bull. 8. pp. 59–69, March, 1918.)—French regulations require a.c. meters to be tested on frequencies varying ± 5 % from the normal value, and this range is often exceeded in actual supply networks. Even a small percentage error in meters is a serious matter where thousands of kw. are supplied through a single meter. The author cites the classic formula derived by P. Janet for the disc speed of an induction meter and discusses the effect and relations of the factors involved. A complete theoretical examination of the problem is greatly complicated by many factors which the author discusses in detail. Complex as the problem is where single-phase meters are concerned, it is yet further complicated by the use of two or three systems of electromagnets in 8-phase meters, owing to the reaction between phases.

It is shown that the lower the ohmic resistance of the pressure magnet windings, the less important the function of the lag coil, and the lower the

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temperature coefficient of the pressure winding. Experimental investigation of the whole problem is much simpler than theoretical analysis, and the author describes his procedure and results. The normal frequency of the meters tested varied from 42 to 58 cycles per sec., and was not always the value marked on the nameplate. Curves are given showing meter errors at various frequencies and for various power factors. The curves for each meter intersect more or less nearly at the point corresponding to normal frequency; as to whether the error is positive or negative, depends on the power factor. The author claims that among the meters tested, French makes gave the best results; 40 % of the French meters and 72 % of the foreign meters required more or less adjustment before they would pass the official tests.

Theoretically the meter speed increases with the frequency, but actual calibration curves in the original show that usually the meter tends to run slow above normal frequency on unity power factor, and fast on 0·5 power factor.

In addition to variations in frequency, the effect of variations in wave-form must be considered. Cases have been known in which meters were correct at a certain time of day but showed 15 % error a few hours later owing to an alternator of different wave-form being employed. Pressure variations may produce an error (varying with power factor) of about 1 % for $\pm$ 10 % variation in voltage. Whereas Thomson meters have a temperature coefficient of about 0·3 % per 1 deg. C., induction meters have an error of about 1 % for 20 deg. C. temperature-rise, at unity power factor, this small value being due to the compensating effect by which temperature changes produce practically equal variation in both driving and braking torques. Another source of error is phase displacement due to transformers used with the meter.

The author considers that ordinary induction meters, which are very robust and cheap, are quite suitable for the majority of consumers, an error of $\pm$ 3 % being unimportant where the consumption is small. On the other hand, the importance of a small percentage on large amounts of energy is such that large consumers and supply authorities alike would welcome special meters of higher accuracy even if the meters themselves were quite expensive. A very small improvement in accuracy would quite outweigh the higher first cost of the meters. The use of two meters in series gives only a limited safeguard because short-circuits, frequency variations and so forth produce the same effects in both meters. More useful practice is to connect in series two meters of different types. Standardisation difficulties are considerable, particularly when it is necessary to take into account the fluctuations of commercial supply. R. E. N.

401. *Edge Effect in Copper Bars.* (Frank. Inst., J. 185. pp. 417–419, March, 1918.)—Measurements are described of the extra resistance due to non-uniform current density in large copper bars carrying alternating currents at 60 and 25 cycles per sec. The bars were in lengths of 20 ft. and of cross-section 4 in. × ¼ in., such as are commonly used for bus-bars. Simple rectangular loops were constructed with the outgoing and return conductors 25·5 in. apart and with a length of loop of 58·8 ft. It was found difficult to measure the a.c. resistance of the loop owing to its low value, but eventually the value was obtained at currents between 100 and 350 amps. in sufficient agreement by three different methods, the resistance ratio (a.c. to d.c.) being 1·3 and 1·1 at 60 and 24 cycles per sec. respectively. This

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increase of resistance is almost entirely attributable to edge effect, the skin effect at these frequencies being negligible. The alternating current is distributed so as to crowd towards the edges of the strip and away from the middle of the width. Shorter loops 19·3 ft. long with sides 2 in. apart were constructed with the sides composed of three bars in parallel and clamped 0·25 in. apart; when tested at 1000 amps. 61 cycles per sec. the resistance ratio was found to be 2·2. A. J. M.

402. *Losses in Iron Sheets at High Frequencies.* **M. Latour.** (Soc. Int. Élect., Bull. 8. pp. 71–81, March, 1918. Rev. Gén. d'Él. 3. pp. 539–548, April 13, 1918.)—A mathematical paper dealing with the calculation of the hysteresis and eddy-current losses in iron sheets when magnetised at high frequencies. The influence of hysteresis on the eddy currents, and *vice versa*, is taken into consideration. It is assumed that the flux and current waves are sinusoidal, *i.e.* the permeability is constant, and that hysteresis causes a phase difference between these waves. The hysteresis loss is taken to vary as the square of the flux density.

Expressions are found for (*a*) the flux density at any point within a plate, (*b*) the apparent permeability, (*c*) the hysteresis loss, and (*d*) the eddy-current loss. It is shown that when the frequency is increased indefinitely, the ratio of the hysteresis loss to the eddy-current loss tends to the value $\sin\theta$, where θ is the phase displacement of the flux and current waves caused by hysteresis: and that, when there is no hysteresis, the formulæ reduce to those obtained by J. J. Thomson.

The thickness of plate giving minimum total losses for an iron core of fixed cross-sectional area (including insulation), is calculated for various values of the hysteretic phase angle θ. Thus when $\mu = 2000$, $\rho = 4 \times 10^4$, $\omega = 2\pi \times 30{,}000$, t (thickness of insulation) $= 0{\cdot}03$ mm. and $\sin\theta = 0{\cdot}5$, the optimum thickness is 0·0375 mm.

The phase difference between the voltage and current in an iron-cored coil is considered (1) when the core is a closed magnetic circuit, (2) when an open magnetic circuit; the amp.-turns being the same in each case. In the first case the phase angle tends towards the value $(\pi/4 - \theta/2)$ as the frequency is increased indefinitely, *i.e.* the power factor of the coil, neglecting ohmic losses, approaches the value $\cos(\pi/4 - \theta/2)$. In the second case the limiting phase angle is given by $\cos\phi' = \cos\phi \times 1/k$, where $\cos\phi$ is the power factor for a closed core, and k is the ratio of the reluctance of an open core to that of a closed core. N. W. M.

403. *Characteristics of Dielectrics.* **C. A. Butman.** (El. World, 71. pp. 812–815, April 20, 1918.)—Since further development of electrical apparatus depends on the provision of good insulation, the author has made a thorough examination of a few dielectrics. Fullerboard and paraffin oil, used separately and combined were the materials studied. It was found that the dielectric strength of fullerboard in oil depends on the time of application, and on the temperature. While the power factor of micarta increases with voltage, that of fullerboard decreases.

The dielectric constant of a heterogeneous combination—such as four fullerboards soaked in oil separated by three layers of paraffin—was found to be greater than that of either component alone (combination = 4·25, fullerboard = 3·32, paraffin = 3·09).

The dielectric strength of paraffin oil was tested over a wide range of temperature. A transition-point was noted at the melting-point (— 12° C.);

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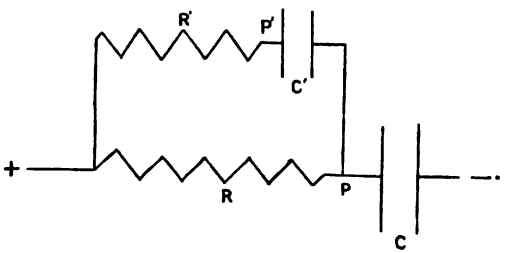
the dielectric strength then begins to increase; there is a second transition-point in the neighbourhood of 50° C., the dielectric strength remaining nearly constant to 100° C., after which it again falls rapidly. Contrary to expectation, the dielectric constant of paraffin oil was found to increase with rise of temperature with a transition-point about 50° C., after which the increase is more rapid.

It was found that with paraffin oil the current becomes proportional to the voltage at about 58° C., which is the transition-point for the oil; below this the proportionality is departed from, the amount being greater the higher the potential used; this suggests that below the transition-point the dissociation is not complete, and there are not enough ions to carry the current. The author believes that all the dielectric properties of paraffin oil can be explained on the basis of polarisation and ionisation, and gives his reasons for this view. A series of curves are given showing the experimental results. The work was carried out by means of the high-potential, low-frequency series induction bridge described in an earlier paper [Abs. 888 (1918)]. V. C.

404. *Excess Voltage in D.C. Circuit without Self-induction.* **H. Chaumat.** (Comptes Rendus, 166. pp. 113–115, Jan. 21, 1918. Rev. Gén. d'Él. 3. pp. 203–204, Feb. 9, 1918.)—The author has noted, and here accounts quantitatively for, phenomena which appeared novel occurring in insulation measurements by the method of accumulation. The circuit shown in the Fig. contains only the non-inductive resistances R and R′ and the con-



densers of capacities C and C′, and can be completed as indicated through a battery of negligible resistance and e.m.f. E. Then, when V and V′ are the potentials of the points P and P′ at time t, reckoned from the instant of completing the circuit, it is found that:—(1) If $V' = 0$ when $t = 0$, it rises to E at time T, to 2E at time 2T, and finally falls asymptotically to E as t increases indefinitely; (2) $V' - V$ attains a max. value at the time T, after which C′ begins to discharge, and $V' - V$ falls asymptotically to zero. G. W. DE T.

405. *High-tension Direct Current from A.C. Supply.* **H. Greinacher.** (Schweiz. Elektrot. Verein., Bull. 9. pp. 85–88, April, 1918.)—The author describes the arrangement and characteristics of an equipment by which a direct current of 0·01 amp. or so at 10,000 volts is obtainable from a.c. supply. The d.c. pressure is practically constant within a wide range of load. Referring to the Fig., an a.c. source L is connected through a variable resistance to a transformer which feeds a bridge circuit of condensers C_1C_2 and oppositely connected electrolytic valves V_1V_2. Direct current is taken from the terminals K_1K_2, and the pulsations in the rectified supply do not become apparent until the current exceeds, say, $\frac{1}{100}$ amp., the condensers

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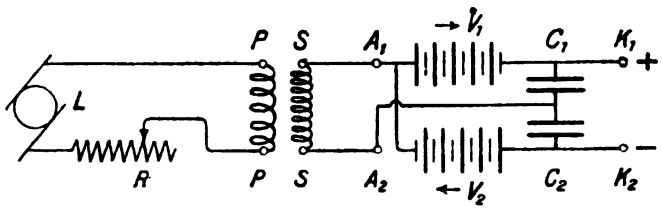
C_1C_2 being about 1 mfd. Each set of valves V comprises about 70 cells in series. Each cell consists of a small test-tube containing a solution of $NaHCO_3$ and electrodes of iron and Al. The average voltage per rectifier cell is less than 100 volts. In an improved form, for portable use, non-spillable electrolyte is used. A spark-gap, coated with weakly radio-active material (to prevent lag in action), is set to limit the max. voltage to about 10,000 volts.

Allowing for resistance drop in the rectifier cells, the d.c. voltage is about twice the secondary pressure of the transformer feeding the rectifier circuit. The use of two sets of valves yields much more uniform d.c. voltage than is obtainable from a single set. The uniformity of voltage is affected by three factors :—(1) Voltage fluctuations in the a.c. supply ; the d.c. fluctuations are, however, reduced in amplitude by the condensers. (2) The rectifying action of the "valves" is not perfect, and becomes worse at overloads of current or voltage. A thread galvanometer shows the effect of this if a current of 8 milliamps. at 8000 volts be taken from the equipment here described. (3) Even on open circuit there are very small periodic variations in pressure owing to imperfect valve action. The periodic variation may be regarded as an alternating pressure superimposed on a constant voltage. Between 500 and 600 volts the variable component is only about 0·1 %, and it is about the same for a current of 8 milliamps. at 8000 volts.



As compared with the usual high-tension battery of storage cells, the present equipment is much cheaper in first cost and needs neither charging nor appreciable maintenance. Even after months of idleness, the rectifying properties of the cells are fully restored within 15 mins. or so from the time of connecting the a.c. supply. The apparatus is not damaged by short-circuiting the d.c. terminals ; it is absolutely "dead" until the a.c. supply is connected ; and any desired d.c. pressure may be obtained by varying the a.c. voltage. There are no moving parts, the apparatus is light and compact, and the current output available is relatively heavy.

The applications of the apparatus include provision of static pressure ; charging and testing condensers ; production of constant electric field (in work on radio-activity, ionisation, etc.) ; testing high-tension insulation (cables, insulators) ; provision of current for measurements and calibration ; and production of electric discharges for experimental and technical purposes. Apparatus is being developed for yet higher pressures and should find useful application in Röntgen practice. R. E. N.

406. *The Technical Story of the Frequencies.* **B. G. Lamme.** (Am. I. E. E., Proc. 37. pp. 1-21, Jan., 1918.)—The various frequencies used in alternating-current work in America are first mentioned, and the primary reasons for their introduction are given.

It is shown that there was an apparent need for two standard frequencies in the region of 60 and 25 cycles, and, further, why 60 and 25 cycles have prevailed. The special fields of application of each one are discussed fully and it is shown why 25 cycles tended to dominate the field.

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The persistent developments of the designing engineers gradually overcame the limitations in various types of 60-cycle apparatus so that eventually the 60-cycle system in its application approached more and more closely to the 25-cycle and, in the end, has taken the lead.

The outcome of the battle of the frequencies was determined far more by the conditions in the operating field than by the exploitation of any particular system by designing engineers. AUTHOR.

407. *Calculations of High-tension Cables.* **W. Kummer.** (Elekt. Zeits. 39. pp. 84–87, Feb. 28, 1918.)—The complex method of calculating high-tension cables has the defect of not being easily capable of physical interpretation. The results are now put into a form in which the superposition of the no-load and short-circuit conditions can be clearly seen. The mathematical treatment is not suitable for abstraction and appears to contain some misprints. A. J. M.

408. *Compression Rheostats.* **A. H. Allen.** (Eng. Club Philadelphia, J. 35. pp. 187–188, April, 1918.)—Apart from the risk of breakage due to oxidation, crystallisation, and vibration, the great objection to sectional rheostats is that a more or less decided change is made in the resistance as one section after another is switched in or out of circuit. Compression rheostats yield continuous gradation of current control; whereas a sectional resistance with many steps is costly, and one with few stops gives poor control and is subject to considerable sparking. The characteristics of carbon as a material for compression rheostats include: Low internal and high contact resistance; good resistance to oxidation, when away from circulating air; no plastic stage when hot, hence no liability to weld together; chemically inert, unaffected by moisture, not subject to corrosion; high specific heat; negative temperature coefficient.

The Allen-Bradley rheostats use graphite discs treated with a suitable reagent to yield high surface resistance and to maintain the latter at high temperature. The discs are placed in a steel tube which has a refractory cement lining and is closed at both ends. A compressing plunger carries a graphite contact block, and compression is performed by a lever or by a threaded screw-head and hand wheel. Compression is exerted to 200 lbs. per sq. in., the resistance obtained being:—No. 1 register 0·0000635 ohm in 55 different registers to 16·71168 ohms per joint. Standard $1\frac{1}{16}$-in. tubes will carry 30 amps.; and $1\frac{1}{4}$-in. and $1\frac{7}{8}$-in. tubes will carry 60 amps. per tube. For higher currents, tubes are connected in parallel or series-parallel. Usually a resistance range of 100 to 1 is provided, but 200 to 1 may be obtained by using selected graphite discs. The apparatus is best restricted to intermittent service. The surface for heat radiation is limited and the negative temperature coefficient of resistance is inconvenient in generator rheostats and speed-setting field rheostats for motors.

Compression rheostats are suitable for all types of d.c. and a.c. hand starters, crane controllers, automatic starters, and battery-charging rheostats. Motors benefit mechanically and electrically by the smooth control provided. Jarring is beneficial rather than otherwise to the rheostat. After a time the surface resistance of the graphite discs changes, but the discs generally last several years before needing replacement. R. E. N.

409. *Motors for Shipbuilding Plant.* **D. Elwell.** (El. World, 71. pp. 506–509, March 9, 1918.)—This gives a description of the electrical equipment of

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the Staten Island Shipbuilding Co., where the various machines have individual drives. Direct-current motors were originally used, but certain alterations were necessary as to site, and the opportunity was taken to revise the whole scheme and substitute a.c. motors. This led to a reconsideration of the question of rating the motors for the different tools. A table is given showing a list of the tools, together with the d.c. motors, and also the a.c. motors which have been substituted for them. Full particulars are given of the work done by each machine, of the rating, pulleys, speed, etc., of the different motors, and of their input when starting, running light, and on normal work. In almost all cases the original d.c. motors have been found to be unnecessarily large, and smaller a.c. motors are now being used.

W. H. S.

410. *A Modern Electrically Equipped Granary.* G. E. Baxter. (Electrician, 80. pp. 572–578, Jan. 18, and pp. 600–602, Jan. 25, 1918. Extracts from paper read before Inst. of Eng. and Shipbuilders in Scotland.)—A detailed description with sectional views of the equipment of the Clyde Trustees' new granary at Meadowside, having a capacity of 31,000 tons of wheat stored in 12 floors. The building is 312 ft. long by 72 ft. wide inside, divided into 2 portions, one 168 ft. long containing silos and bins, and another 144 ft. devoted to floor storage. The capacity of the bins ranges from 20 to 275 tons, and the silos have an aggregate capacity of 20,000 tons. In the floor portion of the building can be stored 11,000 tons of grain in bulk or sections on eleven floors. The machinery, which comprises ship-discharging elevators and longitudinal conveyor bands, also sack conveyor bands, is fully described. The entire plant for the stacked grain has a capacity of 1000 sacks per hour. It comprises two inclined conveyors rising from the floor of the goods shed at an angle of about 17°. The equipment is electrically driven by totally enclosed d.c. 500-volt motors with dust-proof bearings; each has an overload capacity of 25 % for half an hour and 50 % for 5 minutes, without sparking. The insulation is of the Admiralty type. There are 87 motors in all, varying from 5 to 65 b.h.p. and aggregating 860 b.h.p. Details of the current used in discharging, weighing and delivering wheat from the hold of the vessel into one of the bins are given in a table in the original article. An electrically driven traverser of the sunk type is used for handling the 18-ton (gross weight) railway wagons about the granary. This has the extreme length of travel of 100 ft., and the speed at full load is 180 ft. per min. The traverser is driven by 12 b.h.p. 450 r.p.m. compound-wound motors. Current is supplied by overhead bare wires carried on four steel poles, and is collected by a double-armed trolley mounted on the traverser. W. E. W.

411. *The National Industrial Research Laboratory.* R. T. Glazebrook. (Engineering, 105. pp. 252–256, March 8, and pp. 293–295, March 15, 1918.) Lectures delivered before the Roy. Inst. Abstracts in Electrician, 80. pp. 767–768, March 15, and pp. 784–785, March 22, 1918. Nature, 101. pp. 74–77, March 28, and pp. 96–98, April 4, 1918.)—Indicates how the National Physical Laboratory may grow both as a National Research Laboratory and a National Proving House and Standardising Laboratory. L. H. W.

412. *Adapting Induction Meters to a New Frequency.* E. L. Fischer. (El. World, 71. pp. 457–458, March 2, 1918.)—Since this operation is not likely often to be put into practice on any considerable scale, those interested should refer to the original article. L. H. W.

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GENERATORS, MOTORS, AND TRANSFORMERS.

413. *Operating Temperatures in Large Alternators.* **H. D. Stephens.** (El. World, 71. pp. 663–664, March 30, 1918.)—Excessive temperature is one of the chief causes of insulation failure in electrical machinery. The temperature at which deterioration becomes serious has been determined for most commercial insulations, but the difficulty is to decide when this limit is exceeded in practice. Ordinary thermometers cannot be applied conveniently so as to measure the max. working temperature. Resistance measurements merely yield the average temperature of the circuit and give no information concerning hot spots. On the other hand, embedded detectors (thermo-couples or exploring coils) are so effective in measuring the actual temperature of their immediate neighbourhood that they are being standardised in all large alternators having a core of 20 in. and in all machines wound for 5000 volts or over.

One pattern of the exploring coil type of detector consists of a coil of copper wire 5 in. long and of 80 ohms' resistance. Variations in resistance due to temperature change are measured by a bridge arrangement, but it is impossible to make a coil of really satisfactory strength which is yet small enough to measure max. temperatures and not the mean temperature over a considerable area. Thermo-couple detectors measure temperature at practically a point. In the case of core-slot windings, the detector should be placed at the centre of the depth of the winding, this being the point of max. temperature. By using a multi-way switch, any number of detectors can be connected individually to a single indicating instrument but detectors cannot be used satisfactorily in the rotating windings, because moving contacts would introduce serious error with the low voltage and current used in detector circuits. The couples recommended by the author consist of thin ribbons of copper and Advance alloy welded together. The exact positions of points of max. temperature vary even in machines of the same type. The use of detectors is not recommended for small capacity machines. Connection diagrams are given in the original. By giving timely warning of overheating, detectors reduce the number of insulation breakdowns. R. E. N.

414. *Armature Reaction and Leakage in Alternators.* **A. Blondel.** (Comptes Rendus, 166. pp. 138–144, Jan. 28, 1918.)—The alternator is tested at a series of constant terminal voltages on various purely inductive loads. Each curve so obtained gives the excitation required to produce a flux in the axis of the poles corresponding to the voltage and to compensate the effects of the currents in the armature. The latter effects are composed of armature back ampere-turns, the increase of magnetic drop in the air-gap due to leakage in the armature, and the supplementary magnetic drop in the pole yoke produced by the increase of leakage. The curves may also be obtained by running the alternator as an over-excited synchronous motor.

It is shown how, by the aid of the curves, calculations may be made of (1) the excitation required for a given output, (2) the internal phase displacement, and (3) the drop of voltage at a given excitation. The method is compared with that specified by the Rules of the American I. E. E. which is stated to have the drawback of not distinguishing between the direct and transverse armature reaction. A. J. M.

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415. *The Mechanical Oscillations of Synchronous Machines.* **A. Dina.** (Elettrotecnica, 5. pp. 146–151, April 15, 1918.)—In a former article [Abs. 517 (1917)] the author has set forth the theory of the phenomena of the mechanical oscillations of synchronous machines and obtained an expression for the damping couple. In a subsequent article [Abs. 791 (1917)] C. della Salda, treating the same argument, considered the Dina expression as incomplete and substituted for it a new one, which would give a more complete interpretation of the phenomenon.

In the present article Dina demonstrates that della Salda having made some errors, the expression obtained by the latter is inexact. The analysis of the points which, according to the author, would be inexact does not allow of being abstracted. E. B.

416. *Running-down Methods of determining Losses of Machines.* **A. Imhof.** (Schweiz. Elektrot. Verein, Bull. 9. pp. 57–66, March, 1918.)—In obtaining the running-down curves of small machines difficulty is sometimes experienced owing to the shortness of the time taken to come to rest. Two methods are given to meet this difficulty. In one the machine is allowed to run down from a series of different speeds, the length of time taken in each case being measured by a stop-watch. In this manner a number of parallel portions of the whole running-down curve are obtained which can easily be pieced together by shifting them horizontally until the times corresponding to stand-still coincide. The other method consists in deducing the speed from the reading of a voltmeter and noting equal time intervals by a pendulum or metronome and marking with a pencil the positions of the pointer of the voltmeter at the successive equal time intervals. It is then explained how the moment of inertia of the machine may be deduced from a running-down test at no-load and another at a load caused by connecting the armature of the machine across an external resistance. Finally a graphical method is given of constructing curves for the iron losses. The investigations apply particularly to the case of small machines. A. J. M.

417. *Heating of Conductors in Slots.* **G. Perrin.** (Rev. Gén. d'Él. 8. pp. 643–645, May 4, 1918.)—The author works out mathematically a means of calculating the temperature attained by conductors wound in slots, giving a numerical example to illustrate the method. V. C.

418. *Extinguishing Fires in Large Totally Enclosed Generators and Motors.* **M. A. Savage.** (Gen. El. Rev. 21. pp. 53–55, Jan., 1918.)—This article recommends the use of steam for extinguishing fires in windings of large motors and generators where the construction permits of its application. The results of tests show that steam is quite as effective as other substances, such as carbon tetrachloride and carbon dioxide, and is free from their objectionable features. L. H. W.

419. *Air-washers for Turbo-generators.* **L. H. Parker and J. J. Preble.** (El. World, 71. pp. 564–566, March 16, 1918.)—This discusses the advantages of air-washers, and gives information as to their arrangement and origin. The question of cost is also considered, and figures are given as to the cooling effect which is produced. Washers of the spray type should be provided with means for finely atomising the water: high pressures should be avoided; the spray chamber should be completely filled with a dense mass of fine spray, and means should be provided for eliminating all free moisture from the air before it leaves the washer. The drop in air pressure

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through the washer must not be excessive: the allowable pressure at the inlet end should be about ½ in. on the water gauge. The spray chamber should be of proper depth, and the velocity of the air low enough to allow sufficient time for contact between the air and water spray. A 20,000-kw. machine requires 65,000 cub. ft. of air per min., and the cleaning and cooling of this air necessitates the use of apparatus of suitable size and design if proper results are to be obtained. W. H. S.

420. *Polyphase Shunt Motor.* W. C. E. Altes. (Am. I. E. E., Proc. 37. pp. 91–128, Feb., 1918.)—The various forms of a.c. shunt motors are treated. In the analysis of these adjustable-speed motors it is shown (1) that the neutralised motor with shunt field control is not practical for operation on commercial frequencies, on account of the expensive control equipment required; (2) that the induction motor with a commutator on the secondary, while applicable in large sizes, is still too complicated for ordinary machine-tool drives; and (3) that the induction motor with a commutator on the primary side is the most suitable for driving such machine-tools.

The neutralised polyphase commutator conduction motor consists of an armature wound like that of a d.c. machine, and having a polyphase system of brushes on the commutator connected to a neutralising winding that compensates the m.m.f. of the armature winding. The field winding is connected to the secondary of a transformer, the primary of which is connected to the line. Vector diagrams are drawn for the cases in which the field winding and the neutralising winding are in the same slots or in different slots. In the former case the variation of speed is greater than in the latter, when the load is thrown off. It is possible to improve the speed-torque characteristics by using a series transformer, the secondary of which is connected to the field circuit and shifts the time-phase of the flux according to the load current drawn from the line. The characteristics of this motor are particularly favourable when running far above synchronous speed. The reactance of the neutralising winding can be completely compensated by a negative reactance drop in the armature winding. It is impossible to take advantage of the favourable characteristics above synchronous speed in a motor designed for use on a 60-cycle circuit unless the rotor is connected to the secondary of an induction motor, in which case the commutator motor can be supplied at a low frequency and a low voltage, and may be used to control the speed of the induction motor.

If the field winding is located in the same slots as the neutralising winding the motor is more suitable for operation below synchronous speed, and can be used directly on 60-cycle circuits. The field and neutralising winding may be combined into one. A motor of this type has the disadvantage of requiring a transformer that is designed for its full output, and as the ratio of transformation is generally high it is not possible to gain much in the design of the transformer by using the auto-transformer connection. The size of the transformer can, however, be reduced by using a motor of a different type, namely, the induction motor with commutator on the secondary.

In this type of motor the armature reaction is neutralised by induction instead of by conduction. The control is, however, rather complicated, which circumstance renders it rather unsuitable for commercial use. Another type of motor is the induction motor with commutator on the primary side. Instead of changing over the rotor frequency to the line frequency, we can add to the motor a frequency-changer, which makes available at every speed a voltage of the same frequency as the voltage induced in the secondary. This type of

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motor cannot be built for more than 5 h.p. per pole at 60 cycles and 12 h.p. per pole at 25 cycles; in the previous type referred to it is possible to obtain 30 h.p. per pole at 60 cycles and 75 h.p. per pole at 25 cycles. Furthermore, the induction motor with commutator on the primary side can be built for a larger speed-range above synchronous speed than the one with the commutator on the secondary side, and this partly offsets the limitation as to the output per pole obtainable. A. J. M.

421. *Physical Conception of the Operation of the Single-phase Induction Motor.* **B. G. Lamme.** (Am. I. E. E., Proc. 37. pp. 403–434, April, 1918.)—The operation of the single-phase induction motor is examined from the point of view that a pulsating field may be assumed to be composed of two equal fields rotating in opposite directions. Starting from this point of view, it is explained that the rotor current will be composed of two components, one of which is nearly of double the frequency of the main supply, and the second of a very low frequency equal to the slip-frequency. These two components are clearly visible in an oscillogram that is reproduced. A consideration of the magnetomotive forces and magnetic fluxes of the primary and secondary circuits follows, and it is shown that at no-load the primary excitation required is of constant value so long as the secondary circuits are open, but that the primary excitation is doubled as soon as the secondary circuit is closed. The loaded motor is compared to a combination of two separate polyphase motors mounted on the same shaft and connected for rotation in opposite directions. The slip and torque curves of the separate motors are compounded so as to obtain corresponding curves for the single-phase motor. The justification for this method of regarding the loaded motor is examined by means of tests actually carried out on a set of this nature. Eventually it was found that considerable disturbances were introduced that were caused by the large currents developed at low and negative speeds, but when the readings were taken very rapidly so as to eliminate excessive heating, the curves for the torque and slip of the combination were found to agree very well with the calculated curves from the single units combined in the manner explained. A. J. M.

422. *No-load Conditions of Single-phase Induction Motors.* **R. E. Hellmund.** (Am. I. E. E., Proc. 37. pp. 317–401, April, 1918.)—Methods are given for calculating the fields, the stator and rotor magnetising currents, and the tertiary voltages for phase converters and single-phase induction motors at no-load. The fundamental conditions from which the question is approached are: (1) The sum of all counter-e.m.f.'s in any circuit must at any moment be equal and opposite, (2) the rate of change of the flux within a coil at any moment is proportional to the inductive e.m.f. to be induced, and (3) the sum of all the amp.-turns acting upon a certain part of the air-gap is proportional to the magnetic density at that part. Using these assumptions, there is usually only one definite distribution of the resultant field that satisfies the conditions for the primary and secondary windings simultaneously. Having obtained this field distribution the required distribution of the amp.-turns around the circumference follows.

The paper is far too lengthy and detailed for abstraction, and the original should be consulted. The conclusions arrived at are summed up at the end of the article. A. J. M.

423. *Methods of Starting Synchronous Motors.* **T. Sakon.** (El. World, 71. pp. 714–717, April 6, 1918.)—Experiments are described comparing

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various methods of starting synchronous motors by inserting squirrel-cage windings into the pole system. Three different types of windings of this nature are illustrated and described. It is pointed out that an ordinary alternator cannot be made to develop a good starting torque as a synchronous motor by merely adding a squirrel-cage winding, because in the alternator the air-gap is usually too large and the pole span is usually too small to make a satisfactory synchronous motor.

The tests that were carried out are illustrated by oscillograms comparing the starting currents when a synchronous motor is started up with separate excitation and with self-excitation. It is found that with separate excitation the current rises rapidly during the first portion of the pulling-in period and then falls to the normal value. In the case of the self-excited machine the current drops gradually from the value that it took when running as an induction motor to its steady value, without an initial rise occurring. The machine was able to pull into step a larger load with self-excitation than with separate excitation. A. J. M.

424. *Circle Diagram of the Induction Motor.* **O. Bloch.** (Elekt. Zeits. 39. pp. 84–86, Jan. 24, and pp. 42–46, Jan. 31, 1918.)—The Heyland circle diagram of the induction motor is more commonly used than the more accurate Ossanna circle diagram. The reason for this lies in the difficulty of following out the repeated inversions associated with the latter method. In the present article it is shown how it is possible to obtain the Ossanna circle with a single inversion, and it is expected that this simplification will favour the more extensive use of the Ossanna circle. A. J. M.

425. *The Commutator Machine as the Standard Single-phase Type.* **F. Creedy.** (Electrician, 80. pp. 870–871, April 19, and pp. 894–895, April 26, 1918. Abstract of paper read before the Assoc. of Supervising Electricians.)

426. *Increase of Transformer Capacity by Circulating Oil.* **C. H. Shepherd.** (El. World, 71. pp. 560–562, March 16, 1918.)—The author gives his experience at Lincoln Park, Chicago, where certain transformers were seriously overheated, the temperature of the room being sometimes 140° F. Apparatus for cooling the oil was installed, the oil being pumped through coils which were exposed to circulating water. A drawing is given, showing the arrangement of the piping, and the system is fully described. The capacity of the transformers has been increased by 60 %: in the summer the max. temperature of the oil was 106° F. Before the change was effected there was a serious risk of the carbonisation of the insulation. Copper coils, and not iron pipe, should be used in the cooler system. It is considered that the investment in the present cooling equipment (with iron pipes) earns 37 % per annum. W. H. S.

427. *New Distributor Replacing Commutator.* (Rev. Gén. d'Él. 3. pp. 656–657, May 4, 1918.)—The new distributor (French Pat. 488,168 of J. Pestarini) is claimed to be capable of replacing the commutator in existing electrical machinery and to offer a convenient means of converting alternating to direct current or *vice versa*, or direct current at one pressure to direct current at another pressure. The device appears to consist simply of split rings and compound brushes between which resistance is connected, so that short-circuiting is prevented yet the circuit is never broken. The brush resistances may be replaced by inductance, capacity, or an auxiliary alternator. The

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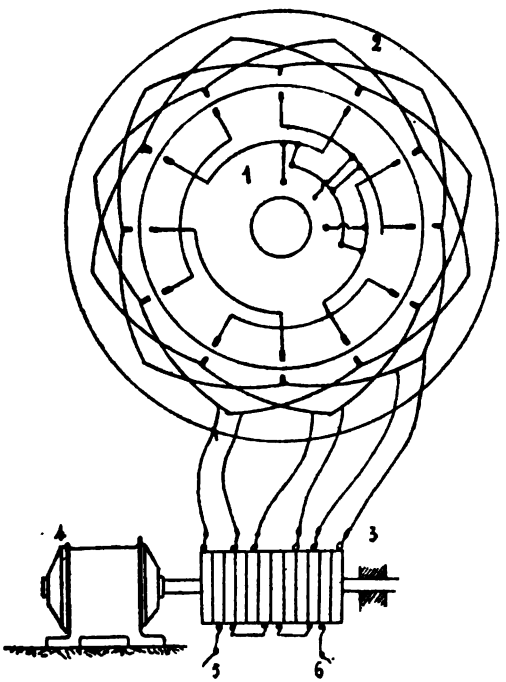
number of sections in the distributor is equal to the number of sections in the winding served, and the effect is to reverse the current at appropriate moments whilst always maintaining the predetermined connection between sections. The distributor may be subdivided into as many groups as there are poles in the winding. The "reversers" of the sections of a given pole are connected in series and form independent groups. At the terminals of the different groups there are equal e.m.f.'s, so the groups may be connected in series or parallel at will.

What is described as a "static" converter for alternating to direct current or *vice versa* is shown in the Fig. On a laminated iron core there are wound,



say, a 8-phase winding (like that of an induction motor) and a d.c. "drum" winding. The sections of the latter are connected to a rotary distributor. Direct current is obtained when the distributor is driven synchronously with regard to the a.c. supply; alternating current at various frequencies is obtained by driving the distributor above or below synchronism. The same arrangement may be used in place of a compensator. The distributor may also be used in place of a motor starter (by connecting the winding sections in series-parallel, etc.); and to convert "statically" the pressure of a direct current; it has also possibilities in the control of squirrel-cage motors.

R. E. N.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

428. *Transmission-line Calculations.* T. A. Williamson. (El. World, 71. pp. 557–558, March 16, 1918.)—In a previous article [Abs. 380 (1918)] the author gave formulæ for the relation between the current and voltage at the two ends of a transmission line. These formulæ involved the complex quantities: $A = a_1 + ja_2$, $B = b_1 + jb_2$, and $C = c_1 + jc_2$. The real and imaginary parts of these expressions were determined in the form of exponentials. The present article is accompanied by charts, by the aid of which each of the quantities A, B, and C and their real and imaginary parts can be read off for given values of the line constants. A. J. M.

429. *Systems of Electric Transmission for Agricultural Purposes.* H. Roth. (Elekt. Zeits. 39. pp. 113–115, March 21, 1918.)—In extensive transmission networks consisting of high, medium, and low-voltage systems, the medium voltage may be regulated by voltage regulators in the substations. As the high voltage cannot always be directly applied to these voltage regulators, the usual method consists in supplying the voltage regulators from the medium voltage system through current transformers. An improvement to this method is suggested by transforming from the high- to the low-voltage system by means of a star-connected transformer, the voltage regulator being connected between the main transformer and its neutral point. In applying the system to the needs of agriculture, calculations are made to determine the area that can be fed from each substation, using differing methods of connecting the agricultural appliances to the line. The particular difficulty in supplying a network for agricultural purposes lies in the fact that the system assumes the nature of a distributing network rather than of a transmission, and this renders the voltage regulation over the area supplied somewhat difficult. Regulation may be effected by installing automatic voltage regulators in a number of distributing substations. These are connected between the medium- and low-voltage systems in the manner indicated above in order to avoid the danger of breakdown in the regulator windings.

A diagram of connections is given showing an installation of this nature suitable for 50,000 volts high voltage, 10,000 volts medium voltage, and 380 volts low voltage. Provision is made for switching off the voltage regulator in case of breakdown, and for regulating the voltage at the point in question from the generating station as long as the breakdown lasts.

The area that can be fed from any substation depends on the regulation of voltage drop, and this again depends on the manner in which the current is supplied to the area. Two typical cases are considered, each quadrant of a circle with its centre at the substation being supplied by a feeder running along its middle line. In the first case the loads are taken off from distributors running at right angles to this central line; in the second case the distributors are connected at right angles to one another and lie parallel to the rectangular boundaries of the quadrant. These are considered to be extreme cases, and the areas that can be fed on these lines, with the same voltage drop, are compared. Particular cases are worked out, showing the areas served as a function of the voltage of the supply and of the section of the cables. It is proved that for a given voltage the section of the copper varies with the third

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power of the radius of the area that can be served, and, furthermore, that the area that can be served varies with the 3/2 power of the voltage chosen. As the medium voltage is reduced the number of substations must be increased and the cost of the substations and feeders will rise in consequence. On the other hand, the medium-voltage network, the transformers, and the transformer houses will become cheaper. On this account the optimum value of the medium voltage must be determined by calculation in each particular case. It has been found by experience that with a high-voltage supply at 30,000 and 50,000 volts the most economical values to be assigned to the medium voltage are about 6000 and 10,000 volts respectively. A. J. M.

430. *Three-phase Four-wire Distribution.* **G. E. Wagner.** (El. Rev., Chicago, 72. pp. 671-675, April 20, 1918.)—The author discusses the economies, advantages, and precautions relating to the distribution of 3-phase energy over 4 wires. In this system, polyphase transformers are connected in star on the primary side and in delta on the secondary; single-phase transformers are connected between phase wire and neutral; and the latter should be earthed. The weight of copper required by various transmission systems for equal load is as follows:—Single-phase, 100; two-phase 4-wire, 100; two-phase 3-wire, 72·9; three-phase 3-wire, 75·0; three-phase 4-wire, 33·3. The 3-phase 4-wire system in general use has 4000 volts between phase wires and 2300 volts between phase wire and neutral. The size of wire required by the 4-wire system for the same load and with the same permissible drop is one-third of that required for 3-wire distribution. If a 4-wire circuit is used for power only, 3 wires are sufficient, but the neutral wire must be provided if single-phase transformers are to be used. If two 1-phase 2300-volt circuits are combined to form a 2300/4000-volt 4-wire circuit, the capacity of the 3-phase circuit is three times that of the two 1-phase circuits combined. The higher voltage of a 4-wire system necessitates extra insulation on underground lines.

Changing from 3-wire to 4-wire system does not alter the voltage on the step-down transformers; hence the same transformers may be used. Owing to Y-connection and the simplicity of regulation, the 4-wire system can be used to supply lighting, heating, and power from one circuit. To protect all parts of the circuit against excessive voltage to ground and to protect single-phase lighting transformers against excessive voltage, the neutral of a 3-phase 4-wire circuit should be grounded at the station and at a sufficient number of points along the line. The neutral of 3-phase transformer banks should be isolated. When the neutral of a 3-phase transformer bank is connected to the neutral wire, the delta-connected secondaries tend to equalise phase voltages; hence this should not be done except on large transformers. Where a single-phase load is supplied from one phase of delta-connected secondaries of a 3-phase bank, the transformer on that phase supplies about half the 1-phase current and the other two transformers supply the balance, whether or not the primary neutral is connected to the neutral wire. The principal advantage of 3-phase 4-wire distribution is that it combines increased line voltage with Y-connection. R. E. N.

431. *Harmonics in Polyphase Systems.* **V. Karapetoff.** (El. World, 71. pp. 660-662, March 30, 1918. Paper read before the Am. Assoc. for Advancement of Science.)—The effects of higher harmonics in 3-phase systems have been treated extensively and recently by J. Damien [Abs. 55 (1918)] and L. N. Robinson [Abs. 198 (1918)]. The present article extends

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the investigations to the general case of symmetrical m-phase systems. particular reference being made to the phenomenon of the oscillating neutral and the effect of secondary mesh currents on the magnetising currents of transformers. Lastly, the combination of polyphase e.m.f.'s in interlinked magnetic circuits is referred to.

If E be the voltage of the nth harmonic between consecutive lines in a m-phase system, and e the corresponding voltage of these lines to the neutral point, then $E = 2e \sin(\pi nk/m)$, where k is an integer. This general case is applied to particular cases by assigning special values to the quantities k, n and m. If $k = 1$ and $n/m = p$ (an integer), then $E = 0$, which is a generalisation of the fact that no harmonics that are multiples of 3 exist in the delta voltage in a 3-phase system. If $kn/m = p + 0{\cdot}5$, where p is an integer, then $E = 2e$. If $n = m$, all the voltages e are in time-phase with each other, and if the neutral point of the generator be grounded and the neutral point of the load be insulated the potential of the insulated neutral point will then vary periodically above and below that of the ground at the frequency of the nth harmonic. This phenomenon is known as the "oscillating neutral." It is also caused by harmonics of the order $2m$, $3m$, etc. If the neutral point of the load be also grounded, considerable currents of the above frequencies will flow through the ground.

When the windings are connected in mesh the total voltage in the mesh will be zero, except when n is a multiple of m, in which case circulating currents of the orders m, $2m$, $3m$, etc., may be formed.

The effect of hysteresis is to make the magnetising current wave of a transformer unsymmetrical. If the neutral point is insulated some of the harmonics cannot flow, and in this case the counter-e.m.f. of the transformers cannot be sinusoidal, but must contain harmonics of the order m, $2m$, $3m$, etc. If the secondary windings of the transformers be mesh-connected, circulating currents will flow. If the iron circuits of the different phases be interlinked with common yokes for the return of the flux, the harmonic fluxes have to find closed paths through the air. If a polyphase machine has windings in each phase consisting of two conductors 180 electrical degrees apart, the magnetomotive force will have a rectangular space distribution along the air-gap. This distribution may be replaced by a series of sinusoidal distributions. If the space frequency of one of these higher harmonics be denoted by N, it may be replaced by two equal magnetomotive forces gliding synchronously in space in opposite directions. If the fundamental flux be supposed to glide from right to left, the harmonics gliding to the left will follow each other at an angle $2\pi(N-1)/m$, and those gliding to the right will follow each other at an angle $2\pi(N+1)/m$. If $(N \pm 1)$ be a multiple of m, the harmonics will not have a resultant equal to zero; thus in a m-phase winding with purely sinusoidal magnetising currents and with the main flux travelling to the left, the only harmonics that can be present in the fluxes will be of the order $a(m+1)$ travelling to the left and $a(m-1)$ travelling to the right, where a is an integer. Particularly, in a 3-phase winding the flux harmonics that are multiples of 3 are absent, the seventh, thirteenth, nineteenth, etc., harmonics glide with the main flux, while the fifth, eleventh, seventeenth, etc., harmonics glide against it.

If the magnetising current possesses an nth harmonic in time, the corresponding flux components move with n times the speed of the main flux. The resultant wave will be zero unless $N = n$, or $(N \pm n)$ is a multiple of m. The magnetomotive force waves for which $N = n$ are of par-

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ticular interest because their direction and speed of rotation are the same as for the fundamental m.m.f., and they cause a permanent distortion of the revolving flux. For other harmonics the speed of rotation is n/N times that of the fundamental, and their effect is often wiped out by eddy currents induced in the rotor bars or in some other part of the machine.

Another interesting case is when N and n are each multiples of m. In this case both the right- and left-going flux waves are equal, and, added together, produce a stationary pulsating flux. For example, in a 3-phase induction motor the third harmonic of the magnetising current ($n = 3$) causes part of the third and ninth harmonics of the flux ($N = 3$ or 9) to be stationary in space. A. J. M.

432. *Reduction of Duct Temperatures.* (El. World, 71. pp. 823–824, April 27, 1918.)—Numerous cable failures due to a sudden increase of load on a high-voltage transmission system precipitated the study of possible methods of cooling. The author gives the safe internal temperature of an 11,000-volt cable as 150° F.; beyond this temperature, the heat due to dielectric losses increases very rapidly to the failure point. Two methods of cooling were suggested: (*a*) by water, (*b*) by air. The first was rejected owing to danger from electrolysis. The section on which the tests were carried out consisted of ten tile ducts, two wide and five deep, with eight No. 4/0 3-phase, 11,000-volt cables installed; there was consequently very little free air to move. The length of the section is under a mile; and 11 blowers, each having a capacity of 612 cub. ft. per min. were installed at the manholes. It was found that the motors became overloaded if air was drawn out of the holes, so the process was reversed and air forced in at alternate manholes, the intervening holes being left open. A reduction of temperature from 125° to 96° F. during the hot months was effected by this means, and the number of failures on this section has been enormously reduced, though the cooler summer, slight decrease of load, and grounding of the neutral may also have been contributing causes. V. C.

433. *Predetermination of Generating Costs.* **B. Soschinski.** (Elekt. Zeits. 39. pp. 125–126, March 28, and pp. 135–137, April 4, 1918.)—The economic problem of central stations is to secure maximum surplus of receipts over expenses, this surplus being a complex function of the selling price per unit. Reducing the selling price results in increased sales and this in turn reduces generating costs. The difficulty is to predetermine the reduced generating costs so that the lowest selling price which will yield a sound return may be ascertained with reasonable accuracy. There are too many variables to permit of an exact mathematical solution to the problem and, in particular, the increase in connections resulting from decreased price per unit is indefinite. By making various assumptions it is possible to obtain linear relations between certain variables, and to express others by rectangular hyperbolic functions. Klingenberg has evolved a means of predetermining working costs assuming equal generating units [see Abs. 1029 (1912)], but the author's method covers the perfectly general case (with unequal sizes of generating units), and permits costs to be evaluated for a number of years ahead. A tariff suited to the desired or anticipated development can thus be framed with considerable accuracy.

The author analyses the problem under three headings, viz. (1) Coal consumption characteristic of a generator. (2) Mean coal consumption per kw.-hr. (3) Predetermination of the load constants. Formulæ are derived

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for the coal consumption of the boiler under all conditions of load. It is impossible to abstract usefully the analytical portions of this paper; a number of special operating "factors" are introduced. Klingenberg's limiting cases [viz (*a*) only one machine or all existing machines permanently in circuit; (*b*) all machines in circuit fully loaded all the time], are not realised in practice. Actual conditions lie between these extremes and suitable load constants may be derived from the annual load curve in which bus-bar load is plotted against time. Rossander has shown that for municipal lighting stations and overland stations with not too high mean load factor, the load curve can be represented by an exponential equation: Load $= a + b\lambda$ (where a, b and λ are constants), if the maximum, minimum, and mean loads be known. On this as basis, the author shows how to predetermine future costs from the values given by experience to date. An example is given for normal cases and for the special case of a uniform load from bulk consumers. The latter sometimes take a fairly steady load throughout the 24 hrs., but this special case can be met by using an exponential curve for other consumers and superimposing the steady load. The author suggests that valuable data would be obtained if stations would apply his method to their past development so as to compare predicted results with those since achieved. R. E. N.

484. *Interconnection of Power Supply Companies.* (El. Rev., Chicago, 72. pp. 413–417, March 9, 1918.)—This is a general discussion of proposals, made in the United States, for the interconnection of supply, which is expected to result in economy and an extension of facilities for the supply of power. In consequence of the fuel question, the proposals are at the moment mainly connected with the question of the hydro-electric stations: about 50 % of the water-power developed up to the present is in the 5 following States: California, Washington, New York, Pennsylvania, and South Carolina. The article contains maps, showing what has been done in certain localities in the two first-mentioned States, and makes general suggestions as to the probable course interconnection will take. W. H. S.

485. *Methods of Charging for Electrical Energy, taking into Consideration the Consumer's cos ϕ.* P. Boucherot. (Rev. Gén. d'Él. 3. pp. 88–89, Jan. 19, 1918.)—The first part of the paper forms a criticism of Arno's method of charging according to the complex load [Abs. 1097 (1910)]. The author then shows that the introduction of a small self-induction in the pressure circuit of a meter of the wattmeter type will enable the reactive power in the consumer's circuit to be taken into consideration. L. H. W.

486. *The Improvement of the Power Factor of a Large Distribution System.* F. Scoumanne. (Rev. Gén. d'Él. 3. pp. 211–227, Feb. 9, and pp. 261–301, Feb. 23, 1918.)—The author deals with the system of the Société "Force électrique," of Baku, where, for various reasons, the power factor of the system is very low (0·55). The problem is discussed at great length, and the conclusion reached is that, from almost all points of view, the static condenser is to be preferred to the synchronous condenser for the purpose of raising the power factor. L. H. W.

487. *New Flash Suppressor.* N. W. Storer and F. T. Hague. (El. Rly. J. 51. pp. 858–860, May 4, 1918.)—A new "flash suppressor" is being installed in the 3000-volt substations of the Chicago, Milwaukee and St. Paul Railway to protect machines against injury by the current output exceeding a pre-

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determined value. The device differs radically from circuit-opening and reactance-inserting devices. It consists of a set of small contactors arranged to short-circuit the armature windings of the d.c. generator through three collector rings connected in 3-phase relationship. The device is actuated and tripped like a circuit-breaker, but the contacts are small and light; they have only a short travel and carry current only momentarily when the device operates. Also, the flash suppressor *closes* a circuit, which is a different matter from opening one and quenching the arc. The contactor can be made to close in 0·006 to 0·008 sec., which is fast enough to prevent a flash from spreading on any but high-frequency machines.

The two functions of the flash suppressor are: (1) to short-circuit the collector rings, thus reducing the voltage between commutator bars to practically zero; (2) to cut down the effective field flux, this being accomplished by the large wattless current which flows through the armature windings when the collector rings are short-circuited. The stored energy of line and machine is short-circuited through and dissipated in the machine. The d.c. circuit-breaker at the switchboard is opened automatically; but the voltage being reduced to practically zero, there are neither surges in the line nor damage to the circuit-breaker.

Oscillograph records represent and explain the action of the suppressor which consists in short-circuiting the a.c. side of the generator a few thousandths of a second after a d.c. overload is applied. The a.c. short-circuit not only arrests the increase of current fed into the d.c. short-circuit, but actually reduces the current nearly to zero for an instant. This, together with the reduced voltage between commutator bars, stops any arc which has already been started by the direct current. R. E. N.

438. *Savings effected by Automatic Substations.* H. E. Davis. (El. Rly. J. 51. pp. 692–695, April 16, 1918.)—This is an account of the results produced by making a certain substation work automatically on the Oneida line of the Utica–Syracuse Railway. There are four substations on this line: it was not possible to select a certain one for automatic working, as power is purchased at this point, and an attendant must consequently be on the spot. Estimates are given showing results to be expected from making any one of the other three automatic: on the plan adopted, the loss of time to the trains is about 2 mins., whereas with either of the others it would be considerably more. It was found that the estimates showed that the net saving effected by making one of them automatic is greater than by operating two or three automatically. Naturally this result depends on a variety of local conditions, such as rate of wages, the capacity of the substations, etc. Figures, plans, estimates, and records of voltage tests are given. W. H. S.

439. *The Automatic Hydroelectric Plant.* J. M. Drabelle and L. B. Bonnett. (Am. I. E. E., Proc. 37. pp. 497–507, May, 1918. El. Rev. 82. pp. 598–599, June 21, 1918. Engineering, 105. pp. 786–789, June 28, 1918.)—The automatic hydroelectric generating station of the Iowa Railway and Light Co. at Cedar Rapids, Iowa, is a radical step in advance in the elimination of operator's wages in a station of appreciable size, without sacrificing complete control.

This station consists of three 400-kw., 500-kv.a., 60-rev. per min., 2300-volt, vertical generating units, tied in to a system, of which the main generating station contains about 20,000 kv.a. in steam turbo-generators. One striking feature is the entire omission of the usual governors, the waterwheel gates being motor-driven and controlled by contact-making ammeters. Each unit

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has its individual control panel, consisting of the necessary contactors and relays to connect it to the bus-bar at the proper time. A motor-driven drum controller gives the proper time element between the different steps in the operation of placing the generator on the line. Any generator can be started either by a float switch when the pond-level reaches the proper height or by a remote control button in the steam station. The starting of the first generator throws on the line the motor of one of the two exciter sets, and the generator cannot be connected to the bus until the excitation voltage has reached the normal value. The waterwheel gates are then partly opened and the generator comes up to approximately normal speed. It is then connected to the bus without field through an iron-core reactance. Then a weak field is applied. Next it is raised to full normal value, and then the reactance is short-circuited. The contact-making ammeter opens the gates to full gate opening and the generator then carries full load in about 40 secs. after either the control button is closed or the float switch is closed. AUTHORS.

440. *The Turbo-electric Ship "Wulsty Castle."* (Engineer, 125, pp. 423–426, May 17, 1918.)—An illustrated description of the equipment of this cargo vessel of 6600 tons deadweight. The Ljungström turbo-electric transmission arrangement is employed. The speed is 10 knots with a shaft h.p. of 1500. As compared with a similar vessel fitted with reciprocating engines the saving in weight of machinery is claimed to be 100 tons, and the net annual saving 7 % per annum on the cost of the ship. L. H. W.

441. *Comparative Costs of Wood, Steel, and Concrete Poles.* **F L. Haushalter.** (El. Rev., Chicago, 72. pp. 587–589, April 6; pp. — —, April 13, and pp. 667–670, April 20, 1918.)—This article deals with poles which are supposed to be used on telegraph, telephone, or low-voltage power lines under urban or interurban conditions, but not in swampy or mountainous country. The first section deals with the comparative annual charges for wood poles, especially cedar and chestnut, while the question of comparison between treated and untreated poles is considered in the second. The third article discusses the cost of several types of steel and concrete poles. The author considers that treated wood poles are the best, partly because the tree has been naturally adapted to resist stresses precisely similar to those to which pole lines are exposed. Concrete poles compare favourably with steel poles at the prices and costs worked out by the author, but something depends on local conditions and needs. The figures would have to be varied considerably if wooden poles had to be set in rock or on pavements; and if the concrete had to be used in very mountainous districts the cost of carriage would add materially to the figures, which apply only to normal conditions. Little is known as yet as to the life of concrete poles, though it has been found that moisture absorption and repeated drying-out affect certain grades of concrete. The life of steel embedded in concrete is thought to be practically indefinite. The greatest disadvantage in connection with concrete poles is the fact that they are of great weight, and cannot be so readily transported as steel poles; they are therefore usually made on the ground where they are to be used: there is also the difficulty of obtaining good sand and water. W. H. S.

442. *Effects of War Conditions on Cost and Quality of Electric Service.* **L. S. Goodman and W. B. Jackson.** (Am. I. E. E., Proc. 37. pp. 23–39, Jan., 1918.)

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443. *Electric Power for Oil-field Requirements.* **J. W. Burford.** (Engineering, 105. pp. 612–618, May 31, 1918. Paper read before the Inst. of Petroleum Technologists, May, 1918.)

ELECTRICITY WORKS AND TRACTION SYSTEMS.

444. 3000-*Volt Gearless Locomotive for Chicago, Milwaukee and St. Paul Railway.* **A. H. Armstrong.** (El. Rly. J. 51. pp. 561–564, March 23, 1918. Abs. of paper read before the New York Railroad Club, March, 1918.)—This locomotive has 14 axles, of which 12 are drivers and 2 are guiding axles. The armature is mounted directly on the axle and constitutes the only dead weight, which is 9500 lbs., as compared with 17,000 lbs. on the driving axles of the present geared locomotives now in operation on this line. The motors are connected 8 in series, giving 1000 volts per commutator for full speed; but the control also permits a connection of 4, 6, and 12 motors in series for fractional-speed operation. The speed characteristics on various gradients are given. The continuous tractive effort is 42,000 lbs. The geared locomotives at present in use have a motor-generator set for exciting the motor field while regenerating; but this has not been found to be essential and the control for the new locomotive will dispense with this feature. Curves show a comparison of the efficiencies of gearless and geared locomotives; the present is the first instance of the adoption of the gearless type on mountain service, the gradient being in places 1 in 50. There are no gears, quills, jack-shafts, or side rods; this increases reliability and reduces the charges for repairs. W. H. S.

445. 180-*Ton Locomotive for the New Haven Railroad.* **E. R. Hill.** (El. Rly. J. 51. pp. 556–559, March 23, 1918. Abs. of paper read before the New York Railroad Club, March, 1918.)—All the data for the new type of locomotive to be used on the New Haven Railroad, are given in this article, including figures relating both to design and construction. The new engines are substantially duplicates of those previously used, except that there are three pairs of drivers on each truck instead of two, and pony axles are used at both ends of each truck instead of being at the outer ends only. The motors are connected in groups of three permanently in series, and the speed characteristics are substantially the same as those of the original gearless locomotives. They are of the a.c.–d.c. type: max. speed, 70 miles/hr.; weight, 362,000 lbs.; rigid wheel-base, 14 ft. 8 in.; total wheel-base, 59 ft. 6 in.; diam. of driving wheels, 5 ft. 8 in.; diam. of driving axles, 8 in. There are 12 motors with quill gearing giving 2025 continuous h.p., and a continuous tractive effort of 14,500 lbs.; gear ratio, 27 : 87; schedule speed, about 40 miles/hr.; train weights, up to 900 tons. For train heating, the locomotives are equipped with flash-type kerosene-fired boilers, capable of evaporating 4200 lbs. of water per hour. W. H. S.

446. 266-*Ton Locomotive for Chicago, Milwaukee and St. Paul Railway.* **F. H. Shepard.** (El. Rly. J. 51. pp. 559–561, March 23, 1918. Abs. of paper read before the New York Railroad Club, March, 1918.)—The continuous capacity is 3200 h.p. with a tractive effort of 49,000 lbs. at 24·5 miles/hr.; the max. starting effort is 110,000 lbs. There are 6 twin motors with quill drive. The overhead contact line delivers current at 3000 volts, and the present arrangement limits the voltage across any commutator to 750 volts. The motors are mounted above the driving axles, and are thus more accessible and less liable to injury; they are mounted rigidly on the frames, and there is

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thus greater flexibility between the roadbed and motors. The centre of gravity is 8 ft. 7½ in. above the rails. There is a minimum number of gears and no necessity for spring gears. There is a battery and two independent sources of low-tension energy for the operation of train lighting, and excitation of the fields of the main motors for regeneration. Diagrams are given showing the characteristic curves of the motors for quill-drive, the transfer of weight on the axles by drawbar pull, a typical starting current graph, and the elevation and plan of the general arrangement. The question of weight distribution is also explained by diagram and discussed. W. H. S.

447. *Loads Combined to Gain Economy.* (El. Rly. J. 51. pp. 264–267, Feb. 9, and pp. 314–317, Feb. 16, 1918.)—The West Penn Railways and the American Gas and Electric Co. have combined their interests to obtain the economy of large generating units in one station at Windsor, W. Va. Each company takes its supply through its own outdoor step-up and metering sub-station. A plan and elevation show the lay-out of the station. The whole plant will consist of six 30,000-kw. turbines and 24 boilers. Each boiler has 12,625 sq. ft. heating surface, economiser, and balanced draught system. The induced draught fan is driven by a 60-h.p. motor and the forced draught fan by a 100-h.p. motor; regulation is by hand. Under the firing floor, between the boilers, is a coal store in a concrete pit 35 ft. wide by 24 ft. deep, of 2050 tons' capacity. A 12 ft. wide opening allows the coal to be lifted by a 3-yard grab bucket and travelling crane into the hoppers. Steam pressure is 250 lbs. and superheat 250 deg. F. The steam headers are connected to allow supply from the boilers of one unit to the turbine of another. The Sturtevant high-pressure economisers have 8625 sq. ft. surface in two sections, with the space between used as a by-pass, making it more accessible for cleaning and repairs. Three boilers have one steel stack 13 ft. diam. × 146 ft. high. Nearly all the auxiliaries are motor-driven. The condensing system is described. The main electrical connections of the station are described and shown in a diagram. The busbar unit for each generator is equipped with a 5 % reactor between it and other units to limit the interchange of energy. The reactors may be cut in or out automatically by a short-circuiting switch. A further protection against surges is provided by a high-frequency absorber, which is an oil-insulated condenser. [See Abs. 528, 729, and 780 (1917).] W. N. Y. K.

448. *Largest High-head Francis Turbine.* **A. Pfau.** (Power, 47. pp. 174–177, Feb. 5, 1918.)—The hydro-electric equipment installed in the White River plant of the Puget Sound Traction, Light and Power Co., near Sumner, Wash., is described. This plant contains two 18,000-h.p. Francis turbines operating under a net head of 440 ft., which have developed over 44,000 h.p. without any detriment to their efficiency. A new 25,000-h.p. unit is now being installed, which is the largest hydraulic turbine of this type in the world. In order to adhere to the principle of conservation of stored hydraulic energy of this plant, it was necessary to provide hydraulic equipment which is capable of controlling the bulk of the momentary variation of the commercial load of the Puget Sound Traction System. This variation is sometimes very severe, owing to rapid and large changes of the power required by the freight trains of the Puget Sound lines. In order to prevent excessive variations in speed and voltage of the power system, it was necessary to use a very sensitive governor, and to control the gates of the turbine very rapidly. A sudden change in the flow of the water through the pipe lines and tunnel would cause pressure variations that would not only impair the regulation, but

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might accumulate to such an extent as to wreck the whole plant. It was decided to use: (1) A surge reservoir at the end of the tunnel for the purpose of preventing surges set up by the tunnel from materially affecting the pressure in the pipe lines, and *vice versa*. (2) Pressure regulators so combined with the turbines that they permit of a sudden release of the water, otherwise brought to a stop when the governor closes the gates of the turbines quickly. In order to prevent excessive waste of water, these releases or by-passes close slowly and automatically at a rate so adjusted that the flow of water is gradually stopped without causing any appreciable secondary pressure-rises. (3) Air-cushion tanks, which supply hydraulic energy to the turbines when the demand of load is so sudden that the water cannot accelerate in the pipe line sufficiently fast to prevent a serious drop in pressure. The proper combination of these devices, together with a fairly liberal flywheel effect of the revolving parts of the generators, made it possible to attain an accuracy in speed regulation which has been the subject of considerable comment in engineering circles.

After the units were placed in commercial operation, elaborate efficiency and regulation tests were carried out. It was found that the efficiency exceeded 90 % and was still above 80 % at about one-fifth load. The full load of 20,000 h.p. was thrown off suddenly, causing the governor to close the gates quickly. The speed did not rise more than 12 % above normal, and the max. pressure-rise in the pipe line above normal did not exceed 5·5 %, as against a guaranteed pressure-rise of 15 % and a speed rise of 18 %. After five years of continuous service one of these turbines was opened up for careful examination. No repairs whatever were considered necessary, and it was estimated that it would be good for another five years of continuous service under similar conditions.

The results of this examination were so gratifying that it was decided to build the new third unit, practically a duplicate of the first two. The results obtained as regards efficiency and speed regulation encouraged the purchaser to increase the rated h.p. from 18,000 of the original contract to 24,000 without increasing any parts except those directly affected, such as the runner, shafts, guide-vanes, etc. It is expected that 25,000 h.p. will be delivered to the generator shaft, and that both the efficiency and the speed regulation will be at least as good as they are with the first units. C. E. A.

449. *Economy of Electricity over Steam for Power Purposes in and about Mines.* **R. E. Hobart.** (Am. Inst. Mining Eng., Bull. No. 134. pp. 213–221, Feb., 1918.)—A detailed comparison of the uses of steam and electric power in the Mines of the Lehigh Coal and Navigation Co. The original winding engine was driven by a piston-valve steam engine 30 by 60 in. placed 600 ft. from the boilers, which were in two batteries, aggregating 1200 h.p. A week's test of this engine covering 168 hours showed a coal consumption of 1088 lbs. per hour; 1705 cars of coal were hoisted from a depth of 581 ft. During the test period there were 104 idle hours, in the course of which 108,075 lbs. of coal were consumed; the coal consumption per h.p. during idle and working hours was 14·7 lbs. As the result of these tests the Company decided upon electrification, and installed in April 1915 a slip-ring induction-motor hoist which required 2·59 kw.-hrs. per car load raised 268 ft.; this consumption includes line and transformer losses and at 8 mils. per kw.-hr. amounts to $0·0207 per car; the coal per car weighing 8960 lbs. In addition to the hoist, the plant in the workings and at the surface of the mine was electrified, the whole steam installation being superseded. As the result of

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12 months' working there was a saving of $16,702 over steam equipment, and the tonnage hoisted was increased from 343,665 to 435,073 ; the cost of power per ton produced being decreased from $0.1370 to $0.0696. W. E. W.

450. *Developments from the Lake Coleridge Hydro-electric Power Supply.* **L. Birks.** (J. of Science and Technology, New Zealand, 1. pp. 16–26, Jan., 1918. Part of address delivered to the Wellington Philosoph. Soc., June, 1917.)—Describes the growth of the hydro-electric supply from Lake Coleridge and its effects on the industries of the districts supplied. The power plant is to comprise, when complete, four generators of 1500 kw. each, and two of 3000 kw. each. Supply was commenced in Nov. 1914 and in March 1917 the fourth 1500-kw. set was put into service ; the fifth unit, 3000-kw. is now on order. Curves show the growth of the max. load from March 1915 to June 1917. To March 31, 1916, the peak load was 1350 kw., and the annual output 4,960,250 units. The next year the corresponding figures were 4500 kw. and 14,224,960 units. The day load—8 a.m. to 5 p.m.—now exceeds the evening lighting load ; the peak is between 8 a.m, and 9 a.m. The weekly load factor is up to 61 %. The supply is 3-phase, 50 ∿ at 66,000 volts from Lake Coleridge to the main distributing station at Addington, 63 miles distant. The pressure is transformed down to 10,500 volts for six primary distributors of 1000 kw. capacity, in duplicate. The main consumers are the Christchurch City Council and the Tramway Board. The Council retails supply at 400/230 volts, and 3000 volts for large power users ; there is also a direct-current supply. Four steam-driven generators, 750-kw. total capacity, act as stand-by. The result of introducing hydro-electric power has been to reduce the charge for lighting from 5d. to 3d. per unit, and for power from 2½d. to 1d., with wholesale power rates down to ¼d. for day and ⅛d. for night load. Of the 3877 consumers 22 % pay less than 3s. per month. The daily maximum for tramways is 1400 kw., and there are four steam turbines of 2500 kw. aggregate capacity as stand-by ; the saving in cost of power has been £2000 per annum. Other big users of power are freezing works, flour mills, tanneries, dairies, quarries, and hospitals. The conservation of fuel is estimated at 44,000 tons per annum. An electric battery car or lorry is garaged, examined, and charged up every night by the Christchurch City Council at £30 to £60 per annum according to capacity varying from ½ to 3 tons load, *i.e.* 2s. to 4s. per day with a range of 60 miles. A dozen such vehicles are in use, and provision is being made for 500 or 600. Chemical industries are being started for the manufacture of hydrate of iron, caustic soda, hydrochloric acid, etc. Many other processes, including steel smelting, have good prospects. W. N. Y. K.

451. *An Automatic Substation on the Ohio Electric Railway.* **R. J. Wensley.** (El. Rly. J. 51. pp. 707–709, April 13, 1918.)—In this substation rotary converters are started and stopped by contactor switches, controlled by relays. This equipment has been designed and constructed by the Westinghouse Co., to whom the present article is due. Details of the method and a diagram of the connections are given. W. H. S.

ELECTRIC TRACTION AND AUTOMOBOLISM.[1]

452. *Electric Accumulator Traction.* **E. Belloni.** (Elettrotecnica, 5. pp. 174–177, May 5, 1918.)—The author begins by calculating the elements

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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of cost of electric traction with accumulators. Assuming that the normal discharge of a battery takes place in 8 hours, the relation between the capacity r, referred to the normal, and the hours s in which complete discharge takes place can be expressed by the formulæ: $r = 0{\cdot}52 + 0{\cdot}16s$ when $s < 8{\cdot}2$ hours, and $r = 0{\cdot}89 + 0{\cdot}045s$ when $s > 8{\cdot}2$ hours.

If n is the power at the normal 8-hour discharge, the power P at s hours discharge is given by $P = N \times 8r/s$.

Assuming that the cost of a battery of mean normal power is 710 lire per kw., the cost of a battery of power P will be $710 \times P \times s/8r$ lire.

The cost of maintenance can be assumed at $0{\cdot}095P/r^2$ lire.

The cost of energy for charging can be assumed at $0{\cdot}068P$ lire per hour.

The cost of maintenance of the electromechanical apparatus can be calculated as $0{\cdot}006F \times P \times s/r$ per hour.

The interest at 6 % on the battery and motors can be taken as high as $9{\cdot}055P/r$ per hour.

The cost of the kw.-hour is given by the sum of the costs aforesaid.

The cost of the train-km. can be expressed by $C = [k + i/808] \times T \times$ (cost of the kw.-hour), where k represents the kg. per ton on the level, i the gradient per thousand, and T the total weight of the train.

The characteristic curves of the motors will, moreover, furnish the current intensity and the speed as a function of the torque.

The power furnished to the battery when the train goes down an incline can be expressed by the formula $2{\cdot}07\ (i - k)$ watt-hours.

From all these data the author calculates the cost of traction with accumulators, and concludes that it increases rapidly when the speed becomes higher than 40 km./hour and that, consequently, a locomotive for 60 km./hour is not economically desirable. The author considers that it would be convenient to add petrol or benzol engines to accumulator locomotives. The mixed locomotives would have high adherence, powerful torque, and would be economically desirable. E. B.

453. *The Dynamics of Wheel and Track.* **J. Jahn.** (Zeits. Vereines Deutsch. Ing. 62. pp. 121–125, March 16; 145–148, March 23, and pp. 160–163, March 30, 1918.)—The author investigates theoretically and experimentally the laws of motion of a wheel rolling and/or sliding down an inclined plane. In order to eliminate any appreciable effect of air friction etc., the wheel is made heavy (107 kg.) and its form is designed to give high inertia so that the acceleration is reduced, and with it the difficulty and danger of measuring the speed of the heavy wheel. The latter is turned down to form a relatively small-diameter axle on each side and the bearing pressure on the track is high, so as to imitate railway conditions.

Rolling friction was found to be negligible, the wheel starting to roll when the track inclination was less than 0·1°. In order to investigate sliding friction the wheel was fitted with a frame to prevent rotation, the torque on this frame being transferred to the rails by ball-bearing wheels. The wheel would just slide on track inclined at 12·8° to 14·5°, corresponding to $\mu = 0{\cdot}28$ to $0{\cdot}26$. It is found that when the wheel rolls down the slope, slip is very slight until $\alpha = 16°\ 40'$; for steeper inclinations the slip increases rapidly. These tests were made with the rails clean, dry, and bright. Condensed atmospheric moisture reduces the coefficient of friction and the imperceptible film of rust forming during a period of idleness increases friction. The tests show considerable departures from the result of calculation, *e.g.* slip commences when the slope is only 7° and at 2° in exceptional cases.

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The coefficient of friction is not found to vary with speed. Tests were made also with greasy track and with a light wheel. The results of these tests and the applicability of the whole series to railway conditions are discussed in the original.

The fact that slipping commences much sooner than would be expected from theory (and in fact to some extent, however small the slope) is attributed not to the value of μ being low during rolling, but to the effect of circumferential force in compressing (*i.e.* shortening) the track immediately in front of the wheel. The track behind the wheel is placed in tension. In other words, the apparent slip is due to compression of the surface layers of the wheel and track by the circumferential force. Sufficient stress is produced for this action to occur owing to the very small contact surfaces actually operative. As the bearing surfaces are improved by repeated use, the apparent slip decreases. For slopes up to about 16° 40′ the ratio (Circumferential force/Rail pressure) is less than 0·23, the lowest value of the coefficient of friction, and up to this point only apparent slip occurs. For slopes greater than 18° 40′, the upper value (0·26) of the coefficient of friction is exceeded and real slip occurs. Rolling friction increases with the circumferential force.

In a second series of tests, the author uses a load hung by a cord from the wheel, to produce such a circumferential force and such local deformation as yields negative apparent slip. When conditions are so adjusted that there is no circumferential force, there is no slip. In order that the "apparent slip" may be kept quite small in locomotive practice, the ratio (Circumferential force/Rail pressure) must be less than the friction limit and preferably not over 0·15 to 0·165. This is the usual range of German and Austrian practice. Even "apparent" slip increases the steam consumption.

R. E. N.

454. *The Voltage Regulator and Phase-balancer Regulator Equipment of the Philadelphia Electric Co.* **R. M. Carothers.** (Gen. El. Rev. 21. pp. 196–201, March, 1918.)—This equipment distributes over the three phases of the generators, feeding a single-phase railway. The boosters with their exciters maintain constant voltage on one phase and the shunt phase-converter distributes the load to the other two phases. The single-phase load at times reaches the value of 24,000 kv.a.: the results are shown by a recording voltmeter. Photographs of the indicating wattmeter and ammeters show how the phase converter adjusts the load between the three phases. Technical details of the installation together with photographs and drawings are given.

W. H. S.

455. *Improvements in Car Equipment.* **C. W. Squier.** (El. Rly. J. 51. pp. 500–506, March 16, 1918.)—This article mentions points in which improvements have been effected, and directions in which they can be still further extended. They include better mechanical and electrical construction, more efficient methods of lubrication, slotted commutators and high-grade brushes, interpole field windings, self and forced ventilation, reduction in weight, higher grade of insulation, choice of correct gear ratio, lower armature speed, and tapped field windings. Information is given under these heads and instances are adduced, showing how in specific instances these improvements have resulted in increased efficiency and lessened charges for maintenance.

W. H. S.

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ELECTRIC LAMPS AND LIGHTING.

456. *Testing Miners' Lamps.* **H. H. Clark** and **L. C. Ilsley.** (Bureau of Mines, Bull. 131. [53 pp.], Washington, 1917. Engineering, 105. pp. 448–451, April 20, 1918.)—"Approved" lamps have been issued since the spring of 1915. 70,000 such lamps were installed within about a year, and 2000 are now installed weekly. The lamp is to give 0·4 candle (the cap-lamp 1½ lumens, the hand-lamp 3 lumens) for 12 consecutive hours from one battery charge, and the battery is to bear 300 such discharges. The reflectors are not highly polished, because the contrast between bright and dark is then too strong, but are to illuminate a circle of 7 ft., the cone of 130° being free of dark spots and showing certain average illuminations over parts of a diameter. When the bulb is broken, the circuit must immediately be interrupted; the test is made in a case which is strongly made in order to bear the explosion of a gas mixture by breaking the bulb with a tool like a miner's pickaxe; the filament glow must immediately be extinguished. The lamp is suspended in springs in such a way, however, that the circuit cannot accidentally be broken; for this test the lamp is dropped from a height of 6 ft. on a concrete floor. The weight of the cap-lamp is about 4½ lbs.; hand-lamps are heavier. With a 2·5-volt battery the max. possible current must not exceed 125 amps., lest sparking be possible, and in 4-volt lamps not exceed 85 amps., as unintended extinction may result from the movements of the miner, and the electrolyte be spilled when he is picking and shovelling. Picking and shovelling tests are performed by placing the batteries on platforms which are oscillated 72 or 75 times per minute for several hours; there must not be more than one full drop of leakage, not even when the batteries are dropped 6 times on a wooden floor from a height of 3 ft. Very important also is the cord test. There was much trouble with cords working loose or breaking; the cords are so fixed to the battery and to an oscillating frame that the cords are slatted by the movement until the circuit is interrupted, or until the resistance increases tenfold. At first the cords did not bear 30,000 of these cord tests; considerably better results are now obtained. It should be mentioned that the certificates refer to types and classes of lamps, etc., rather than to individual specimens. H. B.

457. *The Curtailment of Electric Lighting.* **P. S. Millar.** (Am. Illum. Eng. Soc., Trans. 13. pp. 111–135; Disc., 135–169, March, 1918.)—The production of electric light uses about 2 % of the coal output of the United States: any practical curtailment is about 3 % of this, which means about 360,000 tons of coal per annum. The author discusses the question as to how far curtailment is practicable or desirable, either by removing or extinguishing lamps or by substituting smaller lamps or efficient for inefficient lamps. He also discusses the proper utilisation of light, the use of good reflecting surfaces, daylight saving, the utilisation of water power (which is mainly practicable in the Western States), and the elimination of small power plants: but these proposals are not, generally speaking, capable of being adopted suddenly. Any drastic curtailment of lighting is considered undesirable on various grounds. A list of publications is given on which the author bases his estimates. In the *discussion*, it was stated that some of the coal at present being burnt was of very poor quality, and it was suggested that poor grades of coal should not be carried by the railways. It was considered that a saving could be effected in the suppression of the illumination of advertising devices. It was suggested that more light rather

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than less is needed in factories, printing offices, and many places of that type. In Philadelphia daylight saving would decrease the lighting load by about 6 % if adopted throughout the year. The savings which are possible by the reduction in use of coal in private houses are much larger than are possible in connection with electric lighting: thus if each family used one shovel-full less of coal, the saving in the United States is estimated at 15,000,000 tons. W. H. S.

458. *Effect on the Eye of Lamps in Opaque Reflectors.* **C. E. Ferree** and **G. Rand.** (Am. Illum. Eng. Soc., Trans. 12. pp. 464–487, Dec., 1917.)—Previous researches dealt with the effect on the eye of translucent reflectors of varying densities, when placed in the line of vision [Abs. 642 (1917)]. The present experiments relate to lamps in opaque reflectors, full tables and diagrams being presented to illustrate the fatiguing effect on the eye of bright surfaces, such as the openings of the reflectors, or marked inequalities in brightness of the areas illuminated. As in previous work the criterion of fatigue is the ratio of the times during which an object fixed by the eye appears respectively clear and blurred. In all cases treated some such progressive fatigue is recorded, but the effect may be diminished by suitable design of the reflector and proper location of the lighting unit. J. S. D.

459. *Effect on the Eye of different Illuminants.* **C. E. Ferree** and **G. Rand.** (Am. Illum. Eng. Soc., Trans. 13. pp. 50–60, Feb., 1918.)—Previous researches have dealt with the influence on the eye of variations in brightness [Abs. 112 and 113 (1916) and preceding Abs.]. The experiments now described refer to a series of lamps yielding light of somewhat different colour, but arranged in a similar manner as regards brightness and contrast. They included various electric incandescent lamps (carbon, tungsten, tungsten with blue bulb) and a kerosene lamp. Results are plotted in terms of "time clear to time blurred" to indicate degree of fatigue as in previous work. The results suggest that the colour is an element of some consequence. The loss of efficiency of the eye, on the above criterion, was least with a tungsten lamp giving a "white" light (5·84), greater with a carbon lamp (7·89) and a kerosene lamp (8·39), and highest with the lamp with blue bulb (13·1). It thus appears that the least fatigue was sustained with the light approaching nearest to white. J. S. D.

460. *Unit of Light.* **H. Armagnat.** (Rev. Gén. d'Él. 3. pp. 603–607, April 27, 1918.)—Discusses the relative merits of the lumen and the mean spherical candle as a rating for electric lamps. J. W. T. W.

461. *Flickering of Electric Lamps.* **K. Simons.** (Electrician, 81. pp. 86–87, May 17, 1918. Abstract from Elekt. Zeits., 1917.)—A translation of the paper dealt with in Abs. 87 (1918).

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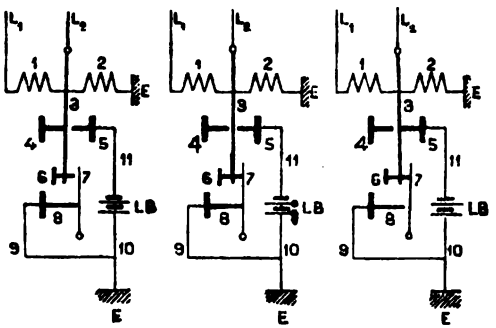
TELEGRAPHY AND TELEPHONY.

462. *Closed-circuit Translation Arrangement for Hughes Typeprinter.* **J. Zelisko.** (Elektrot. u. Maschinenbau, 36. pp. 165–166, April 7, 1918.)—The author points out that uniform signalling conditions are necessary to secure satisfactory working on Hughes circuits. This is best secured by suitable earthing periods after each signal is sent to line. In cases of direct communication between corresponding stations this may be easily arranged for. If, however, the line is so long that an automatic repeater (translator) is necessary, earthing arrangements must be provided there. In the Austrian Telegraph Administration the d'Arlincourt translator has been used hitherto, but this is complicated and requires six relays. The author reduces the number of relays to two by adopting a special construction. Referring to the Fig. it will be seen that the relay has a second or auxiliary tongue 7 which is



normally in contact with an earthed stop 8. The main tongue 3 is connected to the line L_2 while the relay coils 1 and 2 are in series with the line L_1. When a signal is received over L_1 the relay tongue 3 operates, first coming in contact with 7 which rests against 8. Any charge in line L_2 due to a previous signal thus finds a path to earth via 8, 7, and 8. As 3 continues its movement 7 is finally removed from 8 and the earthed battery LB joined to L_2 through 3 and 5. Signals from L_1 are thus repeated into L_2. On the return stroke of 3, 7 again comes in contact with 8 and L_2 is allowed to discharge until 3 comes to rest against 4, when the line L_2 is insulated.

Repeaters constructed on this plan have been in operation for about a year and have proved entirely satisfactory.

The paper includes a plan drawing of the relay and a diagram of the entire repeater arrangement. H. H. H.

463. *Shock Excitation of Electric Circuits.* **J. Bethenod.** (Rev. Gén. d'Él. 3. pp. 499–507, April 6, 1918.)—Many methods have been proposed to obtain the best results with shock excitation of oscillating circuits for wireless telegraphy. The numerous types of dischargers are generally based on the use of very small spark-gaps, and it is generally assumed that the shape of the electrodes is of little importance so long as energetic cooling is applied. The present investigation is carried out in order to deduce from the known properties of sparks the conditions to be fulfilled in order to obtain the best radiotelegraphic signals.

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It is assumed that the characteristic equation for a spark is of the form $v = a + b/i$, where v and i are the voltage and current of the spark. It follows that the energy dissipated in the spark at the time θ is

$$W = a(q_1 - q_0) + b\theta,$$

where q_1 is the quantity of electricity stored in the condenser at the moment considered, and q_0 the initial charge on the condenser. If the discharge is of long duration the equation approximately takes the form $W = b\theta$, and this result agrees with the experimental values of J. Koch. On the other hand, if θ is very small we obtain $W = a(q_1 - q_0)$ approximately. It is this case that is considered in the article.

The equations are worked out for the case of symmetrical and asymmetrical electrodes. It is shown that the conditions of the discharge may be well represented by an experimental arrangement of an inductance and condenser connected in series and discharging through a switch on to a circuit consisting of two branches in parallel, each branch containing an electric valve and a battery, the valves in one circuit being directed in one, and those in the other circuit in the opposite direction, and the batteries in each branch being so connected as to oppose the passage of the currents that are permitted to flow by the valves. It is claimed that this method of representing an oscillating circuit with asymmetrical electrodes has not yet been noticed and that it affords a good method for experimental investigation. This analogous circuit is further used to discuss the question of coupled circuits, and from the mathematical analysis the conditions are deduced for obtaining the best shock excitation in any given case. The equations hold for the case in which the spark is produced immediately after the first passage of the primary current through zero, this being the ideal to be aimed at. The value of the constant a will not always permit of such a perfect operation of the discharger, and one or more further sparks may be produced.

A further article will discuss more fully the mathematical results obtained in the present article. It is, however, pointed out that with asymmetrical electrodes the conditions determining at which voltage the spark will persist or re-establish itself are somewhat complex, and that this voltage depends on the sign of the potential at the terminals of the discharger. It appears that the voltage should not fall below a certain value if it is desired that the primary current should flow for more than one alternation, and that in the case in which a perfect electric valve is interposed in an oscillating circuit (which would correspond to the suppression of one of the parallel branches in the analogous circuit referred to above) the perfect unidirectional valve would not necessarily give rise to an ideal shock excitation, and it is necessary in general for the valve action to take place in both directions as soon as the first alternation is completed. The spark discharger of Wien satisfies these conditions. A. J. M.

464. *Audibility Current of a Telephone Receiver.* **E. W. Washburn.** (Inst. Radio Eng., Proc. 6. pp. 99–104; Disc., 105–109, April, 1918.)—Describes a method of determining the audibility current of a telephone receiver, using a Wheatstone bridge, the arms of which must be practically free from both inductance and capacity. Film resistances serve very well for this purpose. The procedure consists in determining the range of silence on a slide wire, and the method allows a desired percentage accuracy to be secured even when the telephone resistance and impedance are only very

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approximately known. By combining the audibility current, obtained by this method, with the audibility voltage obtained by the shunt method, the tone or audibility impedance of the telephone can be calculated. In the *discussion*, **C. S. Ballantine** gave the results of an investigation of the effect of various wave-forms, and also of the influence of the mechanical movement of the receiver diaphragm on the currents in the windings. The effect of damping, by means of a paper washer, and of the width of the air-gap, is clearly shown by the curves given. **H. A. Frederick** pointed out that by decreasing the resistance of the bridge arms relative to the impedance of the receiver a constant-voltage system may be obtained with any desired precision, and hence the audibility voltage may be determined. [See Abs. 188A (1917).] A. W.

465. *Oscillating Audion Circuits.* **L. A. Hazeltine.** (Inst. Radio Eng., Proc. 6. pp. 63–97 ; Disc., 98, April, 1918.)—The purpose of this paper is to explain the general principles upon which depend the uses of the audion for generating electrical oscillations by "regenerative action," and to discuss in detail the action in certain circuits. It is shown that the criterion for the generation of an oscillation and for the measure of its intensity is directly determinable from the constants of the circuit and from the characteristics of the audion. At the present moment the different connections in which three-electrode valves are used for generating or receiving are very numerous, and the author classifies these into groups so that any particular connection may be referred to its corresponding group. This grouping has the further advantage that new connections are suggested by the systematic manner in which one group of connections is evolved from another.

The first set of connections considered refers to simple oscillation circuits connected inductively or electrostatically to the valve circuit. The second set refers to connections in which coupled circuits are used with the valves, the couplings between the individual circuits and between the circuits and the valve circuit being tight or loose and effected by electromagnetic or electrostatic means. Each type of connection is again subdivided into subsections by the interchanging of the connections to the filament, grid, and plate. In each case formulæ are worked out determining the conditions under which the audion tends to maintain impressed oscillations and the conditions under which the impressed energy will be absorbed. It is found that with certain arrangements the audion will have regenerative action only over a very short range in frequency, absorbing energy from oscillations at all other frequencies. This result affords a means of reducing interference, especially from unsustained oscillations such as are caused by strays.

If I_p is the plate current and E_p and E_g the plate and grid voltages respectively, g the conductance from the grid to the plate, and g_p the quotient of a variation in the plate current by the corresponding variation in the plate potential, then $I_p = E_g g - E_p g_p$. As g_p is usually very small compared to g we may write approximately $I_p = E_g g$. If the plate is positive with respect to the filament there will be an output P from the audion given by $P = E_p I_p$. It therefore follows that $g = P/E_g E_p$. The smaller this quotient the more easily will the audion oscillate, and if the quotient is greater than the value of g obtainable from the audion no free oscillation will occur but externally impressed oscillations may be greatly multiplied. This is known as "regenerative action." If an impressed oscillation cause the grid and plate to be of the same polarity its energy will be absorbed and the audion may thus be used to diminish undesirable oscillations. The form of the quotient giving

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the value of g is symmetrical in E_g and E_p, which shows that the plate and grid potentials are interchangeable. The value of g for given adjustments of the audion depends on E_g, being smaller for higher values of E_g. Hence if the highest possible value of E_g is desired for a given energy of oscillation (as in radio receiving), E_g should be made small relative to E_p. The calculation of the quantity g and the frequency of the oscillations obtainable by means of various connections of the audion is made according to two methods. In the first all currents are assumed to be in phase with one another, and the power loss in each branch is obtained by squaring the current and multiplying it by the resistance of that branch. In this manner the value of P is obtained. If, however, the resistances are high, or the coupling between circuits very loose, or if high accuracy is desired, both the resistances and reactances of the various branches must be considered together. This is carried out in the second method of calculation by the use of complex notation.

One particular connection of the audion is claimed to be novel. This is based on a utilisation of the fact that there are two frequencies of oscillation when the audion is used in connection with coupled circuits. If the audion be allowed to oscillate at one of these natural frequencies while the other is brought into coincidence with that of the signal to be received, the audion may be brought to the verge of changing from one frequency to the other and amplification is then possible. This is called the "self-heterodyne" principle. Another set of novel connections is deduced from circuits already in use by interchanging the plate, filament, and grid with the filament, grid, and plate respectively.

While the author does not claim to have included all possible oscillating audion circuits, he hopes that the methods given will lead to the discovery of new circuits of importance. Two appendices are given. In the first, a graphical method is given for determining the effective mutual conductance g under working conditions, and a "derived characteristic" representing the conditions during an oscillation is obtained from the characteristic curves of the audion, enabling the relations to be obtained between the coil inductances, or between the condenser capacities in the plate and grid circuits, that will result in the greatest power output from the audion when acting as a generator. The second appendix contains a mathematical proof of the fact that the grid and plate of an audion may always be interchanged. **A. J. M.**

466. *Parallel-ohm Measurements.* **E. Roux.** (Jahrb. d. Drahtl. Tele. 12. pp. 462–472, Feb., 1918.)—Describes an investigation of the causes of the various established defects of the so-called parallel ohm method. The calculations were carried out with the simplifying assumption that the phase differences between the individual resistances employed for obtaining the value of the total resistance in use could be neglected, a sufficient criterion being that the ratios were not appreciably altered, as the values of the ratios showed good agreement between calculation and observation; a quantitative investigation was consequently not undertaken. The results of the investigation are, however, not quite conclusive, since calculations and measurements were made for small internal resistances of the detectors; and the greater the internal resistance of the detector, which for galena was about 500–2000, pyrites 1000–8000, perikon 10–4000 ohms, the less important were the variations of resistance of the measuring apparatus and of the detector circuit, and consequently possible errors were reduced. Various improvements in the method are described. **A. W.**

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

JULY 1918.

PRIME MOVERS.

STEAM PLANT.

467. *45,000-kw. Turbine.* (Electrician, 80. p. 878, April 19, 1918. Abstract.)—Gives a few particulars of a 45,000-kw. turbo-generator recently put into service at the South St. plant of the Narragansett Electric Lighting Co. It is of the cross-compound type, and was built by the Westinghouse Co. The high-pressure turbine runs at 1800 revs. per min. and the low-pressure at 1200. Each turbine drives a 22,500-kw. 11,000-volt 3-phase 60-∿ generator. The foundation of structural steel, on piles and concrete, weighs 515,000 lbs. Steam pressure is 200 lbs. per sq. in., and superheat 100 deg. F. There are two No. 24 Westinghouse Leblanc low-level jet condensers condensing 500,000 lbs. of steam per hour at 28 in. vacuum, with cooling water at 70° F. The pumps are turbine-driven. There are 20 B. & W. boilers with seven-retort Taylor stokers. The turbine set weighs 1,880,000 lbs., and the space occupied is 50 ft. × 37 ft. × 18 ft. high. The guaranteed steam consumption under various conditions is tabulated :—

Load, kw.	Percentage of Full Load at 95 % Power Factor.	Lbs. Steam per Kw.-hour.	
		With 28·5 in. Vacuum.	With 29 in. Vacuum.
45,000	100	11·85	11·55
40,000	89	11·75	11·85
35,000	78	11·55	11·20
30,000	67	11·45	11·05
25,000	56	11·60	11·15
20,000	45	11·85	11·35
15,000	34	12·30	11·50

W. N. Y. K.

468. *Value of Higher Steam Pressures.* **J. T. Foster.** (El. World, 71. pp. 977–978, May 11, 1918.)—The original article gives two charts showing the annual saving to be effected by increasing the working steam pressure for electric generating plant. The pressure range covered is from 200 to 700 lbs., with load factor from 50 % up, cost of coal from $3 to $6 per ton, and fixed

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charges from 12 % to 17 %. The percentage increase in the total cost of plant for increase of pressure above 200 lbs. is tabulated :—

	Pressure (lbs.).			
	300.	400.	500.	600.
Boilers	0·75	1·5	2·20	2·90
Turbines	1·40	1·40	1·40	1·40
Condensers	— 0·20	— 0·40	— 0·50	— 0·60
Economisers	nil	nil	nil	nil
Piping	0·50	0·90	1·30	1·70
Total % increase	2·45	3·40	4·40	5·40

W. N. Y. K.

469. *Boiler Equipment of the Auzberg Power Station.* **P. Koch.** (Zeits. f. Dampfkessel. u. Maschinenbetrieb, No. 48, 1917. Elektrot. u. Maschinenbau, 36. p. 158, March 31, 1918. Abstract.)—It was made a condition that the grates should burn Bohemian brown coal economically, and it was found by trial that the Piedbœuf chain grate was most suitable for this fuel. Four Burkhardt vertical-tube boilers are used, each of 400 m.² heating surface and designed for 15 atmos. working pressure with superheater and wrought-iron economiser. Induced draught is provided, and the total grate surface of each boiler is 17·2 m.². Flue ashes are caught in special spirals and removed below the boiler-house floor. The wrought-iron chimney is 29·5 m. high and 1500 mm. internal diam. Butterfly plates below the grate cut off the air supply from part of the grate area at times of light load. The table gives the principal results of three steam trials :—

Test No.	I	II	III
Kg. fuel per m.² grate surface	149·7	199	222
Kg. cals. per hr. per m.² grate	565,000	706,000	800,000
Draught, combustion chamber, mm. of water	2·5	2·7	5·2
Draught, behind economiser, mm. of water	5·2	5·7	10·6
Percentage of Heat	%	%	%
Utilised in boiler	62·9	59·6	59·8
„ superheater	5·8	6·1	7·5
„ economiser	11·8	10·5	11·9
Lost in flue gases	18·2	12·4	15·0
„ ash (unconsumed), radiation, and conduction	6·8	11·4	5·8

A noticeable point is the low draught required. The loss of draught amounts to 2·7, 8, and 5·4 mm. water column at heating-surface loads of 28·8, 38·3, and 38·1 kg. per m.² respectively. During these tests the guaranteed max. power was obtained without artificial draught. R. E. N.

470. *Stresses in Turbine Blading.* **G. Stoney.** (Engineering, 105. pp. 447–448, April 26, 1918.)

GAS, OIL, AND WATER ENGINES.

471. *The Diesel Motor Injection Valve.* **W. Stremme.** (Zeits. Vereines Deutsch. Ing. 62. pp. 111–115, March 9, 1918.)—The influence of the injection valve on the injection performance is considered, and it is shown that the nozzle opening is the basis of standardisation. Standardisation is quite

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feasible and is essential to the bulk production of Diesel motors. Charts are given showing standardised and unstandardised values of nozzle and needle diameters, etc., for Diesel engines ranging from 25 to 200 h.p. per cylinder. One important advantage of standardisation would be the easier obtaining of perfect combustion without repeated trials and adjustments on individual engines. R. E. N.

472. *Submarine Diesel Engines.* **F. C. Sherman.** (Power, 47. pp. 708–710, May 14, 1918. Abstract from the Am. Soc. Naval Eng. J.)—Gives brief notes on sources of troubles arising most frequently in the working of submarine Diesel engines of the two-stroke-cycle Nürnberg type made by the New London Ship and Engine Co. The troubles referred to are: Crank-case explosions; scavenger housing explosions; cracked piston heads, cylinders, pistons, and piston seizures; oil-cooler leakage; wristpin heating; air-compressor defects; valve troubles, and various auxiliaries wearing, etc. W. N. Y. K.

473. *The Autohorse.* (Automotor J. 23. pp. 353–355, May 17, 1918.)—The autohorse consists of a frame attached to the front axle of an ordinary horse-drawn vehicle by a pivotal joint having its axis parallel to the vehicle axle. This frame has a turntable rotatable in it by means of a circular rack and a pinion on the lower end of the steering column. In the middle of the turntable, which bears a cab for the driver, there is fixed on springs a horizontal shaft on which turns a dually-tyred road wheel having on one side an internal gear wheel that is driven by a pinion mounted in a bearing supported on one of the bearings of the road wheel. This pinion is driven through chain and sprocket gearing from one end of a countershaft, the other end of which is connected through a pair of bevel wheels, a Warner 4-speed and reverse-gear box, and a 10-in. Borg and Beck disc clutch to the crankshaft of a monobloc model Continental Motor Co.'s 4-cylinder engine of 3 in. bore × 5 in. stroke giving 20 h.p. at 1000 r.p.m., the radiator of this engine being arranged on the opposite side of the road wheel, *i.e.* on the same side as the internal gear wheel. The autohorse is capable of hauling any load up to 5 tons at an average speed from 7 to 10 miles/hr. C. A.

474. *Air-propeller Action.* **M. Brooks.** (Am. Soc. Mech. Eng., J. 40. p. 390, May, 1918.)—The theory of the marine propeller, which seems to be adequately represented by the screw principle, has been transferred to the case of air propulsion without sufficient regard to the extreme difference between the two fluids as to elasticity. It is found that air may be driven by a propeller at a rate nearly twice that indicated by the product of the pitch of the propeller and its revolutions. The author accounts for this "superspeed" action by suggesting that air, instead of being swept backward by screw pressure is driven back by reflection or "batting" action. Experiments on a special type of wide-blade propeller support this theory, and it is suggested that this interpretation of superspeed may reconcile thrust and power values as derived from static tests with those of wind-tunnel experiments or of flight. J. W. T. W.

475. *Stability of Aeroplanes.* **H. A. Webb.** (Engineering, 105. p. 475, May 3, and p. 587, May 24, 1918.)—Gives a simple proof of the fundamental equations of stability of an aeroplane, using fixed axes. J. W. T. W.

476. *Stability of Aeroplanes.* **H. A. Webb.** (Engineering, 105. p. 587, May 24, 1918.)—A reply to criticisms by W. L. Cowley and H. Levy of the author's simplified proof of the stability of aeroplanes [see preceding Abs.].

 J. W. T. W.

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PROPERTIES OF ENGINEERING MATERIALS.

477. *New System of Reinforcing Metals.* (Engineer, 125. p. 322, April 12, 1918.)—Sheet steel is perforated and covered with copper by electro-deposition to any desired thickness. The plates so produced will stand bending and pressing without separating the copper and iron, and considerable economy in the use of copper can be effected.

Lead can be reinforced by simple rolling into the perforations in steel sheets. Tubing can also be produced and the products used in the making of acid-resisting tanks and pipes. The method has been patented by C. W. Denny. F. C. A. H. L.

478. *New Theory of Plate Springs.* **D. Landau** and **P. H. Parr.** (Frank. Inst., J. 185. pp. 481–508, April, 1918.)—The authors have developed a complete analysis of the theory of leaf spring action which makes possible truly scientific design and yields springs with an endurance far higher than obtainable in springs designed by methods hitherto employed. A brief review of the history of leaf spring theory is followed by a statement of the theory usually accepted to-day, considering each leaf as a cantilever. According to this theory each plate in a spring is subject to the same mathematical probability of concomitant failure, but tests on 33 springs containing from 3 to 18 plates of equal section showed that in 31 cases only one leaf broke and that was always the shortest one. Also, the number of vibrations required to break the spring decreased as the number of leaves increased. Other tests, with springs normally "dead" or "nipless," and with springs using different materials in the leaves, showed that although the durability differed, the short leaf persistently failed first. The new theory analyses completely the behaviour of each leaf and the stress at every point in the leaf, and predicts the endurance of each leaf. Further, the new theory explains all the apparent inconsistencies in past experience and is justified by the great durability already obtained in springs designed on the new principles.

The fundamental assumption of the new theory is that each leaf (excepting the shortest) may be considered as a beam encastré at one end, loaded at the other (by the leaf above it), and flexibly supported at some intermediate point (by the leaf below it). Formulæ are derived which show that the strength of a spring is not nearly in direct proportion to the number of plates; it is also made clear why the short leaf always fails and why endurance at given deflection decreases with increasing number of leaves. The old theory ignores the clamping of leaves at the centre of a semi-elliptic spring or at the end of a cantilever spring. The new theory shows that a two-leaf spring is 1·6 times as strong as a one-leaf spring and that the max. stress in the master leaf cannot be more than four-fifths that in the short leaf. The strength of a 10-leaf spring is only 6·5, and of a 20-leaf spring 12·7 times that of a single leaf. It is a disadvantage to have too many full-length leaves in a spring.

The new theory shows that reactions are far from equal; the deflection errors given by the old theory are much smaller than the stress errors, but serious error may be introduced by ignoring the effect of "stepping" on the deflection. General laws applying to non-tapered leaf springs are: (1) In any leaf spring with leaves of equal section and equal steps, the reactions

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between leaves decrease from the short leaf towards the master leaf, as also do the stresses. (2) In a spring with equal leaf sections, and with equal reactions between leaves, the step-overhangs decrease from the shortest to the master leaf.

A number of useful tables are presented concerning spring stresses and design. R. E. N.

479. *Industrial Preparation of Argon.* **G. Claude.** (Comptes Rendus, 166. pp. 492–494, March 25, 1918.)—In spite of the relative abundance of argon in the air the extraction of this gas by liquefaction processes is very difficult. As argon stands, for the purpose of separation, between oxygen and hydrogen, it escapes in the ordinary apparatus of the author [Abs. 149A (1909)] together with both O and N and only in small proportions; it is possible to obtain almost all the A of the air, but very impure with both the other gases. As meanwhile argon had been isolated for use in glow-lamps in Germany and Holland by the Linde process, the author and Le Rouge resumed their experiments following up suggestions by their late collaborator Lévy. When the mixture of gases escaping from the top of a rectifying column is re-liquefied and the liquid sent down the column, meeting the ascending gases, the most volatile gas is washed out of the gas by the liquid; when the collected gas is liquefied once more, and the process repeated, finally the most condensable gas is obtained in a fairly pure state. In the case of the ternary mixture of N, O, A, the mixture finds in the upper portion of the auxiliary apparatus a bundle of tubes in a bath of liquid N, and the resulting gas is N, not A; in this way Linde gains N, together with A as by-product. By the new process of Le Rouge, the mixture is on the back-flow principle, liquefied in the lower portion of the apparatus in a bath of O. The liquefaction is only partial, and the liquid flows down the vertical tubes; the N thus escapes, and the A and O are treated as first explained, by auto-purification and re-liquefaction, to yield A. The argon thus prepared is of 75 to 80 % and contains, besides O, 1 or 2 % N. This mixture is then burnt with hydrogen to remove the oxygen [Abs. 1767A (1910)]. H. B.

480. *Heat Conduction and the Gas-film Theory.* **H. T. Gillette.** (Engineering and Contracting, 47. pp. 573–576, June 27, 1917. Am. Soc. Mech. Eng., J. 40. pp. 356–357, April, 1918. Abstract.)—In 1912 Langmuir showed that the film of quiescent air adhering to incandescent wires is 0·17 in. thick. The author finds that at low temperatures the equivalent film thickness of water is about 0·05 in., in water which is not stirred mechanically. The equivalent film thickness of steam is apparently much less than that of air, which may explain why water in the ashpit of a boiler increases the fuel efficiency under certain conditions. As used by the author, the term "equivalent film thickness" means that thickness which gives the actual temperature difference assuming for simplicity that each film conducts heat on a linear temperature gradient, as though it were a solid. An example in the original shows the much greater heat resistance offered by the surface air-films compared with the heat resistance of window-glass. Double glazing is so effective in reducing heat losses because there are four air films, only one of which can be reduced in thickness by a strong wind. The author illustrates the application of the film theory to the design of windows and heat-insulated walls, and describes a new type of heat insulator in which the space between hermetically sealed walls is filled with granular or fibrous material and a gas of low conductivity, such as CO_2 or SO_2; such an insulator

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has more than twice the heat resistance of an air-film insulator of equal thickness. R. E. N.

481. *Influence Lines for Continuous Beams.* **G. R. Magnel.** (Engineering, 105. pp. 163–165, Feb. 15, 1918.)—The author, by means of diagrams and examples, shows how to solve the problem of the continuous beam by means of influence lines. He claims that this method enables the problem to be solved with theoretical accuracy in a very few minutes. W. J. C.

482. *Flow of Water in Siphons.* **M. Halliday.** (Inst. Mining Eng. Trans. 54. pp. 107–112, Nov., 1917. Am. Soc. Mech. Eng., J. 40. pp. 193–194, Feb., 1918. Abstract.)—The author considers two cases, that of a single siphon with one pump and an amended arrangement. Diagrams and equations are given for each. The difference in level h_2 between the higher water-level and the top of the siphon, no less than the difference h_3 below the two water-levels governs the discharge of a single siphon. If h_3 be excessive cavitation occurs in the pipe. This explains why some siphons work better when the valve at the delivery end is partly closed. The Nicholson compound siphon is investigated and a condition is derived, subject to which, the compound siphon will discharge as much water as any simple siphon. R. E. N.

483. *New Views of the Combustion of the Volatile Matter in Coal.* **S. H. Katz.** (Bureau of Mines, Techn. Paper No. 183. [15 pp.], Washington, 1918.)

484. *The Determination of Moisture in Coke.* **A. C. Fieldner** and **W. A. Selvig.** (Bureau of Mines, Techn. Paper, No. 148. [14 pp.], Washington, 1917.)—Moisture can be determined quickly and with adequate accuracy ($\pm$ 0·5 %) by simply heating to constant weight a large sample of lump coke, in any convenient oven, or on a stove, hot-plate, or steam coil at a temperature of 100° to 200° C.

Because of its simplicity and flexibility this method may be used advantageously at points where coke shipments are sampled. L. H. W.

485. *Italian Leucitic Lavas as a Source of Potash.* **H. S. Washington.** (Met. and Chem. Eng. 18. pp. 65–71, Jan. 15, 1918.)—Attention is called, as a future possible source of potash, to the leucitic lavas of seven volcanoes along the west coast of Italy, from Bolsena to Vesuvius. The rock types are characterised and the several volcanoes described. It is shown that the leucitic lavas of these volcanoes, with an average potash content of about 9 %, contain at least 8,786,200,000 metric tons of K_2O, making them the greatest accumulation of highly potash-rich silicate rocks known. Methods of extraction of the potash are not discussed. L. H. W.

486. *Design and Progress of the Floating-frame Reduction Gear.* **J. H. Macalpine.** (Inst. Eng. and Shipbuilders, Trans. 61. pp. 46–88, April, 1918.)

487. *Balancing Revolving Elements.* (El. Rev., Chicago, 72. p. 571, March 30, 1918.)—The accompanying chart shows the weight of cast iron or steel removed by holes of various diameters and depths.

The seat and degree of unbalance may be determined by the Akimoff dynamic balancing machine, in which the rotor on test is rotated with a "phantom" rotor which is adjusted to reproduce the conditions of balance

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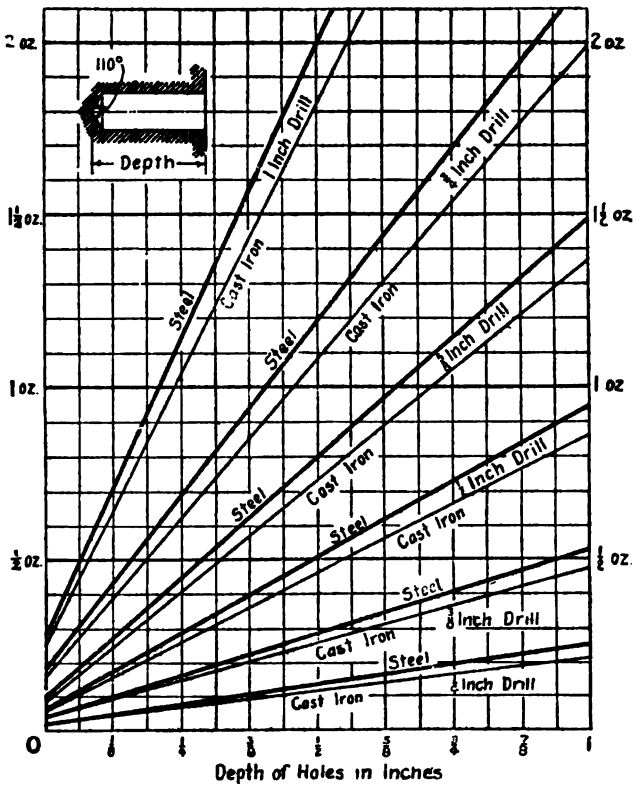
in the actual rotor. By this or other means, it is ascertained that a certain amount of metal should be removed at a certain point to obtain true balance. This being known, the Fig. shows the depth and diam. of hole to be made.



The chart covers depths up to 1 in., diams. from ¼ to 1 in., and weight up to 2·1 oz. per unit hole. It is easy to determine by mere inspection of this chart whether one hole or several had better be drilled in a specific case, and what is the most convenient combination of depth and diameter. R. E. N.

488. *Use of Spruce in Aeroplane Construction.* **J. A. Newlin.** (Aerial Age Weekly, 7. pp. 162–163, April 1, 1918. Am. Soc. Mech. Eng., J. 40. pp. 423–424, May, 1918. Abstract.)—The paper gives general information relative to the species and conditions of growth of spruce, the influence of moisture conditions on aeroplane stock, and the relations of density to moisture content, shrinkage, and strength. It was found that clear wood with specific gravities of 0·33 (based on value when green) or over 0·36 (when based on oven-dry value) would seldom run below 4500 lbs. per sq. in. in modulus of rupture, or below 2000 lbs. per sq. in. in max. crushing strength along the grain when green. Drying to the condition of aeroplane stock would increase these minimum strength figures to about 8000 and 4000 lbs. per sq. in. respectively. Good spruce may be assumed to shrink about 12·5 % from the green to the oven-dry condition. J. W. T. W.

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489. *Pipes closed at Both Extremities. Accumulators and Power Transmitters.* **D. Eydoux.** (Comptes Rendus, 166. pp. 559–562, April 8, 1918.)—Pipes with equilibrium shafts, previously studied by the author, function, from the standpoint of water movement, as pipes open at both extremities. This work has led the author to take up the case of pipes entirely closed, such as are used for transmission of energy by water under pressure. The mathematical results obtained are applied to the case of an accumulator working a press, and to other forms of power transmission. H. H. Ho.

490. *Heat Transmission of Building Materials.* **A. C. Willard and L. C. Lichty.** (Univ. of Illinois, Bull. No. 102. [60 pp.] Nov. 19, 1917.)—The object of the investigation is to determine the coefficients of heat transmission of standard building materials for exterior walls under conditions similar to those of practice. In order to arrive at coefficients of maximum general utility, and to explain the means by which these coefficients may be applied to specific problems, the authors analyse the process by which heat is transmitted through walls. Two cases have to be considered in determining the transmission coefficient: (1) Walls in air which is quite still, save for vertical convection currents set up by the wall itself. (2) Walls in moving air. The authors discuss the general merits and limitations of the following methods of testing:—Ice box; oil box; cold-air box; hot-air box; flat- or hot-plate method. The hot-air box method was chosen for the present investigations, as being best suited to the use of nearly full-size specimens. Thermocouples were used for temperature measurements, and the elaborate nature of the equipment used (described fully in the original) makes the investigations of unusual importance.

Variation in air speed over the surface affects both air-to-air coefficient and outside surface coefficient. The outside surface coefficients of brick and wood are affected in practically the same manner at low air velocities, but the coefficient for brick becomes the higher at higher velocities. The coefficient of transmission for a simple or compound wall, floor, or roof can be computed, provided the surface coefficients are known for still and moving-air conditions. The coefficients of conductivity should also be known from tests on full-size walls for usual temperature ranges. Moving air increases the outer surface coefficient K_2 by the combined action of heat-transfer by radiation and convection. Where the average wind speed during the heating season is about 15 miles/hr., K_2 may be taken $= 3K_1$; where K_1 = inside surface coefficient. The relative humidity of air has an almost negligible effect on the heat transmission of an ordinary building wall. Increased humidity causes a slight increase in the overall transmission coefficient. If a brick wall becomes actually wet its coefficient of conduction may increase at least 25 %. Air-space construction is of value at low but not at high temperatures. Heat transmission across an air space increases rapidly, not only with increased temperature difference between the enclosing walls, but also with the same temperature difference if the absolute values of the wall temperatures are increased. R. E. N.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

491. *Current Efficiency of the Edison Cell.* **M. de K. Thompson** and **L. R. Byrne.** (Am. Electrochem. Soc., Trans. 31. pp. 339–348; Disc., 348–350, 1917.)—The object in view was to investigate the current efficiency of the separate plates in charging an Edison cell. The method used was that of comparing the quantities of hydrogen and oxygen evolved with the amounts of the same gases evolved in a water voltameter. A single cell of the B-4 type was used, having a rated capacity of 80 amp.-hours. The plates consisted of 4 positives and 5 negatives and the normal rate of discharge was 16 amps. The cell had been standing idle for three years before the work was begun. In test No. 1 it was found necessary to pass 446 amp.-hours before the cell was completely charged. The current efficiency of the cell in this case was found to be 48·5 % and in the case of the next test 66·7 %. The conclusions reached are that the Edison cell after standing a long time requires a prolonged charge to bring it back into good condition. At room temperature the efficiency of charging the iron plate is generally greater than that for the nickel plate. At low temperatures the efficiency of charging is reduced. On starting the charge a maximum in the efficiency of both plates is reached in the early part of the charge. W. R. C.

492. *The Bethlehem 10-ton Girod Steel Furnace.* **C. A. Buck.** (Am. Electrochem. Soc., Trans. 31. pp. 81–85; Disc., 85–86, 1917. Met. and Chem. Eng. 16. pp. 578–580, May 15, 1917.)—A detailed description is given of a 10-ton Girod electric steel furnace now in operation at the Bethlehem Steel Co.'s plant in the U.S.A. The furnace is cylindrical in form, made of ¾-in. steel plate, and is approximately 15 ft. in diameter. It is equipped with one counter-balanced charging door, sliding in a water-cooled frame. The tilting is accomplished by a 15-h.p. motor and worm drive. The bottom of the furnace is 20-in. in thickness and is made of dolomite rammed in with tar. The roof is of silica brick. Three 17-in. amorphous carbon electrodes are used, the weight of an electrode being about 1000 lbs. The total weight of the furnace is approximately 90 tons, including 35 tons of refractories. Three-phase current is used, the conducting hearth being used as the neutral point. Special care has been taken to prevent the formation of induced currents in the shell and roof frames. The consumption of cooling water at the furnace is about 20 galls. per min. In the *discussion*, **B. I. Whiting** said that in order to avoid induced currents the direct magnetic loop of the control is broken up by non-magnetic material. The insulation of the column over the shell to prevent short-circuits is made by inserting mica, and this is also placed in the roof of the shell to prevent any possible short-circuiting in case the roof becomes sufficiently hot to become conducting. W. R. C.

493. *Design and Operation of a Small Kjellin Furnace.* **G. H. Stanley** and **W. Buchanan.** (Met. and Chem. Eng. 18. pp. 349–353, April 1, 1918. Abstract of two papers in Chem. Met. and Mining Soc. of S. Africa, J., Sept., 1917 and S. African Inst. of El. Eng., J., Sept., 1917.)—The author describes the way in which a 1-ton Kjellin furnace was constructed in South Africa to supply the need for steel for stamp-mill shoes and dies. The current available was 50-cycle and, therefore, a frequency changer was put down to

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give current of 10 to 15 cycles. It is shown that under the conditions in South Africa this was as cheap as using an electrode type of furnace. Drawings are given showing details of construction. Certain difficulties were experienced in putting the furnace to work. The lining was found to crack and, therefore, the ganister was replaced by tar-chromite mixture, which was rammed in hot. After being put to work for a short time this lining also proved unsatisfactory, however, and was replaced by a magnesite lining made up with clay and boric acid. Details are given of the method adopted in re-lining and of the method of operation. Since the furnace was not made of the tilting type, in order to avoid complication, some trouble was experienced in the metal solidifying in a ladle if a very large one was used. Otherwise it was necessary to use three smaller ones. In order to get over this difficulty a fore-hearth was fitted, into which the complete charge could be run. This fore-hearth consisted practically of a sheet-steel box lined with fireclay and with a bottom outlet. This was controlled by a fireclay plug and could be used conveniently to fill ladles as desired. W. R. C.

494. *Electrical Characteristics of Electric Furnaces.* **A. A. Meyer.** (Am. Electrochem. Soc. Trans. 31. pp. 97–121 ; Disc., 121–180, 1917.)—Results are here given regarding two electric furnaces, one being a 6-ton Héroult furnace and the other a 5-ton Grönwall furnace. The Héroult furnace has an acid lining of silica and is provided with three 17-in. amorphous carbon electrodes for 3-phase working. The leads consist of solid bus-bars, each bar being made up of 8 pieces spaced triangular fashion, coupled up with flexible leads. The latter consist of 9 stranded copper cables in each phase and these are connected to further solid bus-bars, there being 6 bars in each phase ; these are connected to the electrode holders. The Grönwall furnace had a dolomite lining and was provided with 4 electrodes passing through the roof and 1 electrode embedded in the hearth, for 2-phase working.

Recorder diagrams are reproduced showing the load fluctuations, and oscillograms showing the form of the current and potential waves, but the latter are not very clear. The power factor went down to 65 % at the start, coming up subsequently to 85 % and finally to 90 %. The power factor was not very steady.

Oscillograph records on the primary side showed bad current-wave distortions, especially when the load was unbalanced, but the potential wave was not appreciably distorted. Further curves were taken on the secondary side of the transformer. These showed that the distortions of current waves were not very different from those obtained on the primary side. Some further oscillograms were obtained by making the oscillograph a shunt to a portion of the bus-bar, thus eliminating the current transformer. These showed very different results. The shunt method gave current waves much more jagged, with double peaks in the current wave, due to the combined effect of the third and fifth harmonics, which together appeared to be almost equal in amplitude to the fundamental. It was found that as much as 24 % of the pressure was lost in the drop between the transformer and the electrodes, and that the drop was about three times as great in the solid bus-bars as in the flexible leads. Tests were also made with an ordinary d.c. shunted ammeter connected in each electrode circuit of the Grönwall furnace, and in each circuit an apparent direct current was observed. This appeared to be about 70 to 80 % of the total current indicated by the current-transformer ammeter. It was also found that the polarity of this direct current reversed from time to time. In the *discussion*, it was remarked that

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the current in the shunt was 60 degrees out of phase with the current in the furnace leads. **J. R. Craighead** expressed the view that, in regard to metering, more correct results would be obtained by metering on the primary side of the transformers. W. R. C.

495. *Alternating-current Measurements.* **C. O. Gibbon.** (El. World, 71. pp. 979–981, May 11, 1918.)—Describes a null-method of measuring alternating current by means of a bridge, in the arms of which are fixed and moving coils of two exactly similar electrodynamometers. The a.c. supply is connected across the diagonal of the bridge, and across the other diagonal is a d.c. (storage battery) supply, the current from which is variable and measured by means of a potentiometer. When the point of zero deflection on the dynamometers is obtained, the value of the direct current is numerically equal to the r.m.s. value of the alternating current.

J. W. T. W.

496. *The Electrical Equipment of a Car, with Special Reference to American Starting and Lighting Systems.* **A. L. Clayden.** (Inst. Automobile Eng., Proc. 11. pp. 38–75, 1916–17.)

497. *Switchgear Standardisation.* **C. C. Garrard.** (Inst. El. Eng., J. 58. pp. 212–228; Disc., 228–246, April, 1918. Electrician, 80. pp. 706–707, Feb. 22, and pp. 728–729, March 1; Disc., p. 747, March 8, 1918. Abstract.)—The author deals with the subject in a concise manner which does not well admit of further abbreviation; the original should be consulted. L. H. W.

498. *Potential Distribution in String Insulators.* **H. Saegusa.** (Tôhoku Univ., Sci. Reports, 6. pp. 295–306, April, 1918.)—This is a mathematical discussion of the distribution of potential along a string of suspension insulators with capacity between one another and between each insulator and the earth.

According to Peek [Abs. 640 (1912)] it is not possible to increase the number of insulators proportionally to an increaseof voltage, because of the consequent rapidly decreasing "string efficiency," or ratio of the total impressed voltage to z times the max. voltage across an individual link, where z is the number of links. Similar conclusions were arrived at by Rüdenberg [Abs. 766 (1914)]. Both the above investigators considered the case of equally distributed capacity. The present author examines the case in which the capacities are graded, and obtains formulæ and draws curves showing the distribution of the voltage per insulator, and of the voltage of each insulator to earth for strings of various numbers of insulators with various relative values of the series and shunt capacities of the elements of the string. For the purpose of comparison curves are also given for the case of equally distributed series and shunt capacities. It is concluded that by suitable grading of the capacities, any desired distribution of potential and unity value of the string efficiency may be obtained. A. J. M.

499. *Graphic Instruments in Industrial Motor Circuits.* **T. S. Montgomery** and **W. B. Bray.** (El. Rev., Chicago, 72. pp. 831–834, May 18, 1918.)—The plant of the Pacific Portland Cement Co. (Solano Co., Cal.) is driven electrically. Energy is transmitted from the Sierra Nevedas at 60,000 volts and reduced at the works to 2080 volts, which pressure is used for all motors above 20 h.p. Smaller machines are worked at 440 and 110 volts. During the last few years efforts have been concentrated on obtaining max. efficiency from individual machines, and in doing this portable test boards

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with graphic meters have been found very useful. For 440-volt motors the board used has one polyphase integrating wattmeter and an Esterline graphic meter. The 2000-volt board is fitted with ammeters and watt-hour meters. The meter records show the adequacy or otherwise of the motor used, and analyse operating conditions so as to show the good and bad features of the drive. A useful feature of the Esterline instrument is the provision made for altering the rate of paper feed, so that either a day's working can be recorded in small compass or an individual cycle can be analysed in detail. Several examples are given, showing the improvements in operation effected by study and application of the wattmeter records. It pays to install a recording ammeter permanently in the circuit of motors operating under difficult conditions and affected considerably by the personal factor as regards efficiency of manipulation. R. E. N.

500. *Electric Welding in Ship Construction.* (Emergency Fleet News, p. 11, April 29, 1918. Am. Soc. Mech. Eng., J. 40. p. 495, June, 1918. Abstract.)—The application of electric arc welding to shipbuilding is being tested by the Emergency Fleet Corporation at Newark, N.J. A ship has been designed to suit the material available, having the outline, dimensions, and strength of other ships in the course of construction at the same yard. A 10,000-ton ship, costing $2,000,000 now costs $70,000 to rivet, and if electric welding only promises to modify this amount, no very substantial gain offers. The test, however, has in view abolishing or greatly diminishing (1) the railway journey from rolling mill to shipyard, (2) the template markers' work, (3) the markers' work, (4) the punching, (5) much of the work of the fitters and bolters. In these items there is an excellent likelihood of saving a month's time in construction and $40 a ton in the cost of steel structure, or at least $100,000 a hull on a 10,000-ton vessel. The scheme is to assemble a hull rapidly by spot-welding at intervals of about 10 in., the hull then becoming a structure within which work can be carried on continuously in all weathers, and afterwards to weld the seams by arc-welding. Tests will be made on a portion of a hull, of which one-quarter will be riveted and the remainder welded for the purpose of making comparative tests. It is expected that the quantity of steel required will be reduced 10 %. The primary test will consist of filling the hull with water and shifting the points of support under continual and close scrutiny, and the welded and riveted joints will be further tested by bumping with rams and in other ways. R. J. W.-J.

501. *Abac Facilitating Design of Field Rheostats.* **P. Poitrimol.** (Rev. Gén. d'Él. 3. pp. 715–720, May 18, 1918.)—Theoretically, field rheostats should be designed by starting from the characteristics of the machine controlled, but generally they are graduated according to an empirical curve. The author selects the rectangular hyperbola for use in this connection and develops an abac permitting rapid solution of all calculations relating to the design of such a rheostat. It is rarely worth while to design rheostats by the laborious methods dictated by theory, since the increased initial accuracy is sacrificed by variations in the characteristics of individual machines, by the effects of temperature and by variations in magnetic quality of materials. In practice it is generally best to provide a few more steps in the rheostat than are essential, and to adopt a definite gradation of steps whatever the constants of the machines controlled. An exponential curve for the gradation facilitates slide-rule calculation, but this law only holds good when the rheostat resistance is of the same order as that of the field coils; it fails completely in

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the case of relatively high-resistance rheostats. For most cases the best formula is the rectangular hyperbola $R(1 - kp) = R_0$, where R = total resistance of circuit to step p, R_0 = resistance of field coils alone, p = number of stop, reckoned from the short-circuit position, k = coefficient depending on construction of machine and number of rheostat steps. If n be the number of steps chosen and R_n the total resistance to be inserted, we have $R_n(1 - kn) = R_0$, whence k may be determined, R_n and n being known. If constant voltage be applied to the field circuit (as in variable-speed motors and, nearly enough, in self-excited constant-pressure generators) the current $i = U/R = U(1 - kp)/R_0$; *i.e.* it varies linearly from one end of the rheostat to the other. Generally the maker of the machine supplies the following information: (1) Rheostat resistance ($R_n - R_0$); max. and minimum currents $i_0 i_n$: or (2) rheostat resistance ($R_n - R_0$); field resistance R_0 and voltage U.

The author shows how to produce an abac solving the above equations. The chart is too large to be reproduced here satisfactorily; it is rather complicated, but should be useful to those who have to design a number of rheostats and can thus become familiar with the scales. R. E. N.

502. *Cable Section for Intermittent Load.* (Brown-Boveri Mitteil. 4. No. 9, 1917. Elektrot. u. Maschinenbau, 86. p. 181, April 14, 1918. Abstract.)—The problem attacked is the determination of cable section for intermittent operation, particularly in hoist service. The motor-starting current i_h may be taken as constant and equal to $2\frac{1}{2}$ times normal current i_n, during the starting period t_h. The normal current i_n flows for a time t_n and after that there is a period t_a of no current flow. The effective value of the current (as regards heating the cable) is $i_e = \sqrt{\{(i_h^2 t_h + i_n^2 t_n)/T\}}$ where $T = t_h + t_n + t_a$. For very small values of $t_h + t_n$, the effective current is calculated as above and the corresponding cable section is then taken from a V.D.E. table (of German Rules). The permissible current strength i_e and cable sections are tabulated for $(t_h + t_n)/ = 1$ min.; $i_h = 2{\cdot}5 i_n$; $t_h = 5$ secs.; and values of load factor $\alpha = (t_h + t_n)/T = 1:2{\cdot}5$, 1:4, and 1:7. A 25-mm.² cable, which carries only 100 amps. under the V.D.E. rules, will carry 130, 166, and 220 amps. when $\alpha = 1:2{\cdot}5$, 4, and 7 respectively. It is also possible to determine the "on" period permissible if the same cable section be used for intermittent as for steady load.

The value α is determined easily in the case of motors with mechanically operated switchgear (*e.g.* electric runways). If the motor be hand-controlled, the value of α must be chosen with regard to the service and may be $1:2{\cdot}5$ in the case of foundry, erecting and loading cranes; 1:4 for sluice and lock gates, etc.; and 1:7 for motors which are rarely in service. The connections between motor and controller may be smaller still because they are in yet more intermittent service; but the leads must not be so small that the corresponding voltage drop affects seriously the starting of the motor. In order to limit the starting period, maximum time relays may be used, to admit starting current during 5 secs. only. In hoisting service, fuses are used to protect cables and motors and these should be rated at $1\frac{1}{4}$ times normal current to prevent melting during starting. R. E. N.

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GENERATORS, MOTORS, AND TRANSFORMERS.

503. *Flux Distribution in Alternators on Short-circuit.* **N. S. Diamant.** (Am. I. E. E., Proc. 37. pp. 485–496, May, 1918.)—The paper is a lengthy one illustrated by numerous curves, oscillograms, and tables, and is concerned with the distribution of the flux in alternators of the salient pole type during the time of sudden short-circuits. The distribution of the flux is explored by means of 16 search coils wound at different situations on a 6-pole, 3-phase, 45-kv.a., 480-volt machine. These comprise a full-pitch concentrated coil, a number of coils wound round the teeth at different places in the slots and on the faces of the teeth so as to enclose different portions of the faces, and also a number of single turns placed at the top of a tooth, at the top of a wedge, and so forth.

It is pointed out that the e.m.f. induced in the search coils will be a true reproduction of the B-curve if the variation of flux is due only to the motion of the armature. This is not always the case, as there is a superposed variation due to changes in the reluctance of the magnetic circuit of the machine, and also to swinging of the flux wave with respect to the pole axis. This latter effect is a maximum when the pole arc covers an integral number of slot pitches *plus* half a slot pitch. Some of the oscillograms obtained in the full-pitch concentrated search-coil show, besides kinks due to the teeth, a long flat superimposed wave which is supposed to be due to the rotor lying excentrically in the field. A peculiarity of some of the curves that show tooth ripples is the non-uniform spacing of these ripples.

It is concluded that unless the field and armature flux-waves are sinusoidal the resultant field under sudden short-circuit conditions will be badly disturbed, the fundamental being so greatly reduced that the higher harmonics assume a predominant rôle. If the armature currents are sinusoidal in time, the H-curve of the armature reaction will also be sinusoidal, but the B-curve will be flat-topped, according to the degree of saturation, and will be toothed and have different values at surfaces that are at different depths in the slots. The elimination of higher harmonics from the B-curve is very difficult.

The particular magnetic oscillations revealed by the tests are due to (1) the teeth, (2) the excentricity of the rotor (having a frequency $1/p$ times the main frequency in a $2p$-pole machine), (3) armature reaction (with a frequency 6 and 4 times the main frequency in 3- and 2-phase machines respectively), (4) pulsations of magnetic reluctance (these are analysed in detail and show particular differences between the e.m.f.'s induced in search coils at the top and bottom of the slots).

Owing to the phenomena discussed it is difficult to devise means of predetermining certain characteristics of the machine by test or calculation without actually loading it. For example, if the open-circuit core loss of an alternator is 2·8 % of its rating and is equally divided between hysteresis and eddy currents, and if the loss on sudden short-circuit, excluding friction and windage, be 1·5 % the ordinary assumption is that the flux distribution on sudden short-circuit is sinusoidal, and 10 % of the open-circuit value would give a hysteresis loss of 0·035 %, an eddy-current loss of 0·014 %, and a total loss of 0·049 %. If it be next assumed that the fundamental is 5 %, the third harmonic 15 %, and the fifth harmonic 10 %, a similar calculation would give a hysteresis loss of 0·114 %, an eddy-current loss of 0·45 %, and a total loss of 0·564 %.

Thus, according to the first assumption the hysteresis and eddy-current losses are negligible on a sudden short-circuit, being only 3·3 %, but the

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second assumption would give hysteresis and eddy-current losses of 88 % of the total short-circuit test losses. A. J. M.

504. *Method of Synchronising Electric Machines.* **M. Osnos.** (Elektrot. u. Maschinenbau, 35. pp. 29–32, Jan. 21, 1917.)—The article commences with a review of the various methods in use for synchronising electric machines. The new method is a development from one already used, that consists in connecting choking coils in the a.c. leads, bringing the machine to the neighbourhood of synchronism by an auxiliary machine and then gradually exciting. If the choking coils are suitably designed the machine will fall into synchronism after one or two oscillations. When this has taken place the choking coils are short-circuited which gives rise to a considerable current rush. It is also possible to use an induction motor for starting with its windings connected in the place of the choking coils. This causes the reactance to decrease as the machine starts up. Even then considerable rushes occur when the induction motor is short-circuited.

The new process consists in decreasing the reactance of the series choking coils automatically and gradually, to such an extent that practically no current rush takes place when they are short-circuited. A further advantage of the method lies in the freedom of choice of the type of the auxiliary motor.

The reduction of the reactance of the choking coils is effected by superposing a d.c. field upon the a.c. field. Eight diagrams show various methods in which this may be carried out. Direct-current excitation of the choking coils may be drawn from the commutator of the rotary converter that is being started up, and the choking coils may be inserted either on the primary or on the secondary side of the step-down transformers. It is only necessary to use a choking coil in one of the phases in a 3-phase machine. The d.c. excitation may be also derived from any separate source.

The choking coil may be designed with three limbs, the outer ones carrying the alternating current windings and the middle one the d.c. windings. The dimensions of a coil suitable for a 500-kv.a. rotary converter are given.

A. J. M.

505. *Theory of Static Frequency-changers.* **D. Korda.** (Archives des Sciences, 42. pp. 402–417, Nov., 1916.)—A general theory is given of static frequency-changers. The mathematics applies to the general case of a frequency-changer provided with any number of phases. The problem is divided into two distinct cases according as the number of phases in the frequency-changer is an odd number $2k + 1$ or an even number $2k$. In the first instance the polyphase fluxes produce zero magnetic flux in the common core so long as the currents supplied follow the sine law. If harmonics are superposed all the fluxes cancel out except that of a frequency $2k + 1$ times the value of the fundamental frequency. If the polyphase supply has an even number of phases all the harmonics cancel out and the apparatus cannot be used as a frequency-changer. It is preferable not to connect the generator directly to the frequency-changer, but to connect two transformers in series, one having a highly saturated core and the other a very weakly saturated core. By this means polyphase primary currents with $2k + 1$ phases may be transformed into single-phase secondary currents of frequency $2k + 1$ times the primary frequency. In this method secondaries of two transformers are connected in opposition.

The article concludes with the consideration of the case of a flux of trapezoidal form being produced by each phase. The construction carried out shows how the change of frequency is produced and determines the wave-shape of the resulting high-frequency flux. A. J. M.

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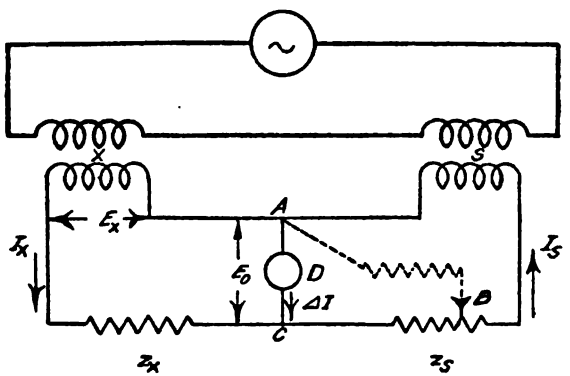
506. *Testing Current-transformers.* **F. B. Silsbee.** (Bureau of Standards, Bull. 15. pp. 317–329 [Sci. Papers No. 309], Washington, 1917.)—Precise laboratory methods for determining the ratio and phase-angle of current transformers require special apparatus (*e.g.* carefully calibrated non-inductive shunts and very sensitive a.c. detectors). The apparatus and procedure are simpler if a transformer be compared with a second transformer taken as standard. The standard transformer should have the same nominal ratio, and its constants should be determined by a precision test. Two or three multiple-range transformers are sufficient for testing a considerable range of transformers, and a commercial wattmeter is sufficiently delicate for use as a detector.

The principle of the new method is illustrated by the Fig. The primaries of the standard and unknown transformer S, X are connected in series and supplied with alternating current. The secondaries are connected in series so as to send current in the same direction, and impedance loads z_s, z_x complete the circuit. A detector D is connected as shown, and the current ΔI



through it equals the vector difference of the secondary currents of the transformers; hence by measuring the phase and magnitude of ΔI, the difference in performance of the transformers may be calculated. The measurement of ΔI may be by a *deflection method*, using as detector one winding of a separately excited wattmeter; or by a *null method* in which a compensating circuit (dotted between A B in the Fig.) is used to reduce the current in the detector circuit to zero. Both these methods are described in detail in the original. In the deflection method, when the secondary currents are nearly equal so that $\Delta I/I_s$ is small, a detector of high impedance and high current sensitivity may be used. On the other hand, if $\Delta I/I_s$ be large, a high-impedance detector may shift the load from the transformer with higher ratio to that with lower ratio. In the null method, the performance of each transformer is the same (when balance is obtained) as if the other transformer were replaced by a short-circuiting link across AC. The principal limitation to the sensitivity attainable in any method of testing current-transformers is the fact that the measuring circuit must not affect the transformer performance by increasing the equivalent secondary load by more than a certain resistance r. A comparison method gives more power for operating the detector than does an absolute method, and the detector may be 50 or 100 times less sensitive in the former case.

Two of the most convenient of many possible modifications of the general method are described, and a comparison of the results obtained, with those from absolute tests, shows very good agreement. R. E. N.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

507. *Effect of Phase-lag on Transmission Lines and Generators.* **A. Leauté.** (Soc. Int. Élect., Bull. 8. pp. 147–164, April, 1918.)—The effect of the war has been to cause overloading of the French generating stations, and unfortunately at the same time the situation has been aggravated by the lowering of the power factor, which has an adverse effect on the output of the alternators. A Committee has been appointed by the Société des Électricens et L'Union des Syndicats to examine this question, and a number of publications have resulted, amongst which are those of Rechniewski [Abs. 208 (1918)] and Boucherot [Abs. 485 (1918)]. The author now examines the manner in which the power transmitted by the feeders and generated by the alternators decreases when the phase displacement becomes excessive.

In the case of short feeders, the heating of the conductors is the only factor limiting the current that can be transmitted, and the power that can be transmitted will, in consequence, vary directly with the cosine of the phase-lag. If, however, the feeders are long enough for the voltage drop to become the principal factor, it is shown that the power that can be transmitted varies as $1/(1 + \tan\phi \tan\theta)$; in which ϕ is the angle of lag of the current behind the voltage and $\tan\theta$ is the ratio between the reactance and the resistance of the line. The ratio of the power that is actually able to be transmitted to the power that would be transmitted at the assumed power factor $\cos\phi_1$ can thus be expressed in terms of three parameters, θ, ϕ, and ϕ_1, in which ϕ_1 is the angle of phase displacement for which the installation was originally designed.

It is shown that the terminal voltage may be to a certain extent maintained by increase of excitation, but that an early limit to this process is set by the field windings. An abac is constructed from which the reduction of power is able to be read off for different values of the parameters. Application of this to a special case shows that if $\phi = 80°$ and $\phi_1 = 60°$, the corresponding reduction in the power is 54 % of the original value in the case of a short feeder, whereas in the case of a long feeder, for which $\tan\theta = 2$ (about the highest value that can be reached in practice), the power is reduced to 48 %. As far as the alternators are concerned, it is shown that in the case of a certain 8-phase alternator for 4000 kw., 5330 kv.a., 25 cycles per sec. and 12,800 volts, a reduction of the power factor from 0·62 to 0·22 will reduce its output to 29·2 %. It is concluded that very great reductions in the output are caused by the lowering of the power factor, and that public authorities should turn their attentien to the problem of maintaining reasonably high values of the power factor. A. J. M.

508. *The Control of Large Amounts of Power.* **E. B. Wedmore.** (Inst. El. Eng., J. 56. pp. 269–292; Disc., 292–324, May, 1918. Engineering, 105. pp. 439–443, April 19, and pp. 469–472, April 26, 1918. Abstracts in Electrician, 80. pp. 742–744, March 8, 1918. El. Rev. 82. pp. 244–246; Disc., 246–247, March 15; 285–286, March 22, and pp. 310–311, March 29, 1918.)—This paper with its seven appendices, followed by a long discussion, can only be abstracted in outline: for details the original paper should be consulted. The problem of maintaining continuity of supply requires the proper proportioning of the impedance of the different parts of the system, and means must be

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found to limit disturbances. This must be done by limiting the power which can be concentrated at a point owing to a fault, and this must be done without excessive cost. The author recommends the extended use of reactances in some form as a method of protection; these can be used either in feeders or generators, or between the bus-bars. Sections deal with each of these methods. There is a limit to the use of generator reactance, as although it reduces the short-circuit current, it does not maintain continuity of supply. Reactances in the feeders and between the bus-bars (either on the "star" or "ring" methods) must therefore be used. The consideration of these points is mainly discussed in the paper, and perhaps in fuller detail in some of the appendices. Inherent reactions should be utilised as far as possible, and additional artificial reactance should be used only to ensure that disturbances shall be sufficiently localised and plant adequately protected against excessive stresses. The appendices give full information as to the arrangement of bus-bars, the limiting of current by the use of bus-bar reactance, and the transfer of loads. Another appendix deals with the heating and stresses due to heavy currents. A great deal of general experience is embodied in the various contributions to the discussion.

W. H. S.

509. *Electric Power Transmission in Agricultural Districts in Germany.* **Block.** (Elekt. Zeits. 39. pp. 144–146, April 11, 1918.)—These are supplementary suggestions by the author, arising out of Klingenberg's proposals [see also Abs. 718 (1916)]. The author suggests the distribution of power from some main source at 100,000 volts: this is to be supplied to the most important distributing centres, from which points power is to be supplied, either directly or indirectly, to the already existing stations. These latter should be connected by lines at pressures between 40,000 and 70,000 volts, and should be used for supplying current at times of max. load. The proposals are at present of the nature of an academic contribution to the study of the question. Some details are given as to its proposed application to some of the provinces of East Prussia, and the supposed advantages of the scheme are emphasised.

W. H. S.

510. *Sag of Wires on Steep Grades.* **A. Still.** (Frank. Inst., J. 185. pp. 509–516, April, 1918. El. Rev., Chicago, 72. pp. 945–947, June 8, 1918.)—Methods are given for calculating the sag of overhead wires when the ends are at very different levels, taking into account the effect of changes of temperature and abnormal loading by wind pressure and the formation of ice on the wires.

If storm conditions produce a stress in the wire n times as great as when the wire is hanging in still air at the same temperature, there would be a reduction in length due to elastic contraction when the extra load is removed. If the removal of the load were accompanied by a rise of temperature the sag would remain the same as in the loaded condition if the temperature were to rise to a certain value, which is called the "critical temperature."

After discussing the usual methods of calculating the sag in wires with their ends at very different levels and showing that these are not sufficiently accurate, a new method is recommended in which the inclined span is considered to be replaced by an equivalent horizontal span of length equal to the actual distance between the points of support. The vertical loading of this imaginary span is now taken as $w \cos \theta$, where θ is the actual inclination of the span to the horizontal and w the actual weight of the wire per unit length. After making this assumption the calculation is carried out as if the span were horizontal. If nw is the loading per ft. of wire

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producing the max. tension P and w is the loading in lbs. per ft. that produces a tension P_1 when the temperature is such that the sag of the conductor hanging in still air is the same as the max. deflection under storm conditions, then $P_1 = P/n$. This factor is given by the relation—

$$n = \sqrt{[(w \cos \theta)^2 + p^2]}/w \cos \theta,$$

in which p is the max. horizontal wind pressure per ft. of wire.

The application of the method is shown by numerical calculations and the results are recorded in a diagrammatic form showing the variation in the sag at different temperatures with the wire horizontal or sloped. A. J. M.

511. *Iron Wire for Transmission Lines.* **W. T. Ryan.** (El. Rev., Chicago, 72. pp. 713–715, April 27, 1918.)—There is a question as to whether in certain cases iron is not preferable to copper at present prices for material and labour. The use of iron means a lower cost of conductors and higher tensile strength; this allows longer pole spacings and economies in poles and insulators. The San Diego Gas and Electric Co. is using 550- and 700-ft. spans with $\frac{1}{4}$, $\frac{5}{16}$, and $\frac{3}{8}$-in. standard 7-strand steel wires on its 11,000-volt extensions. In general, it seems likely that with iron the spans might be 50 % longer. The author considers the questions of the cost of conductors and the relative advantages of copper and iron, which in part depend on the nature of the scheme. Curves are given showing the constants for various sizes of galvanised iron wire and for Siemens-Martin steel cables, which also show the permeability, impedance, reactance, etc., at the stated spacings and temperatures. The Bureau of Standards intends to publish data as to sags and tensions. W. H. S.

512. *Canada's Water Powers.* **J. B. Challies.** (Canad. Elect. News, 27. pp. 21–25, May, 1918.)—A survey of Canadian water powers with special reference to the present shortage of fuel. The following table gives the more important figures :—

Province.	Power Available. H.P.	Power Developed. H.P.
Ontario	5,800,000	789,466
Quebec	6,000,000	520,000
Nova Scotia	100,000	21,412
New Brunswick	800,000	18,890
Prince Edward Island	8,000	500
Manitoba	—	76,250
Saskatchewan	8,500,000	100
Alberta	—	32,860
British Columbia	8,000,000	269,620
Yukon	100,000	12,000
Total	18,808,000	1,785,598

As regards the application of the power already developed, the author states that 78 % of this is used for municipal, domestic, and ordinary industrial purposes; 14 % in the wood pulp and paper industries; and 8 % for electro-chemical and electro-metallurgical purposes.

The further developments of water power in Canada will undoubtedly be extensive, and must depend very largely on :—(1) Additional requirements

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for municipal, industrial, and domestic use. (2) Growth of pulp and paper industry. (3) New electro-chemical and electro-metallurgical processes. (4) Electrification of steam roads, especially terminals and adjacent engine divisions. (5) Substitution of hydroelectric power for power derived from fuel in manufacturing and industrial operations generally. J. B. C. K.

513. *Underground Distribution for Electric Supply Systems.* **G. J. Newton.** (Am. I. E. E., Proc. 37. pp. 208–258, March, 1918.)—Shows each step in the design of an underground electric supply distribution system in the business section of a medium-sized city, taking as an example a system comprising 110–220-volt single-phase lighting, 220-volt 3-phase power, and series street lighting, arc and incandescent. A series of maps of the city show : (1) Load distribution ; (2) Street lighting ; (3) Centres of distribution ; (4) Primary power feeders, 2200 volts ; (5) Three-phase power mains, 220 volts ; (6) Secondary power feeders, 2200 volts ; (7) Lighting feeders, 2200 volts ; (8) Secondary mains, 220 volts ; (9) Bare neutral mains ; (10) Secondary lighting feeders, and (11) Conduit system. The design of these items is discussed in detail and the arrangements of ducts, transformer vaults, and manholes are dealt with. W. N. Y. K.

514. *An Insulated Negative Return Feeder.* **A. P. Way.** (El. Rly. J. 51. pp. 861–862, May 4, 1918.)—This describes in detail the results which have followed in Lynchburg, Virginia, from an insulated negative feeder system, which has now been in use for two years. It was installed to overcome electrolytic defects, and a plan is given, showing the nature of the area which has been dealt with, and the lengths and sizes of the feeders. The layout was designed to make an overall voltage drop of 0·5 per 1000 ft. during the normal period with an average station load of 1150 amps. ; the data were obtained from two maps, one showing the position of all cars at normal operation and the other their position at max. load at 5.30 p.m. The results of the installation have been satisfactory, but no special tests have been carried out. W. H. S.

515. *Effect of Daylight Saving on Load.* (El. World, 71. pp. 972–974, May 11, 1918.)—In the Middle Western United States the following results seem to be noted : The plan of daylight saving does not effect any great saving in coal : a depression is made in the load curve between 5 p.m. and 8 p.m. : there is a reduction of 5 % in the kw.-hrs. : the reduction in revenue is slightly greater than this in consequence of the rates of charging ; it may, in some cases improve the daily load factor, but will reduce the annual load factor, thus affecting the central station financially. Increased rates will have to be charged if the companies are not to suffer. A number of typical load curves under the new conditions are given : these show clearly the depression in the load curve mentioned above. W. H. S.

516. *Copper Economies in Austria.* **F. Sabestsching.** (Elektrot. u. Maschinenbau, 36. p. 167, April 7, 1918.)—A demand was made by the Government for some of the copper and lead (11 tons of the former and 8 of the latter), used on an electric line, 13 km. long, between Bludenz and Sckruns in the Montatoner valley. This could be done either by raising the voltage, which was considered impossible owing to the existing motor equipment, or by altering the method of supplying the line with power. Hydro-electric power was supplied from a point about 800 m. from the one end of the line, and it was found that the required saving could be effected, without

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detriment to the working, by transmitting this power to a point near the middle of the line, where a substation for transforming purposes has been erected. W. H. S.

517. *The Improvement of the Power Factor.* **E. W. Dorey.** (Electrician, 81. pp. 61–63, May 24, and pp. 81–83, May 31, 1918.)—The consumer is mainly responsible for low power factor: this results from the nature of the motors installed, the conditions under which they are worked, their number, size, etc. The consumer should therefore share responsibility for the result, and this should be brought home to him by the method of charging. The charge may be based on the consumption in kv.-amp.-hrs., or on a fixed rental charge per kv.-amp. per quarter *plus* a running charge per B.O.T. unit consumers. The author discusses these methods of charging, and gives particulars of plans proposed. The kv.-amp. demand would be ascertained by suitable instruments of the max. demand type: the results and advantages of this method of charging are discussed. The power factor itself may be dealt with by methods under the control of the central station. Rotary converters or synchronous motor-generators may be used in place of induction motor-generators: synchronous motors may be preferred to induction motors where possible: or some form of power-factor rectifier or condenser may be used. Under the last head may be included a phase advancer, operating in conjunction with a slip-ring induction motor: or a static condenser: or a specially constructed synchronous motor, running light on the mains at approximately zero power factor, commonly called a rotary condenser. These various expedients are considered from all points of view, but the nature of the solution to be adopted depends partly on the circumstances of the particular case. W. H. S.

518. *Localisation of Faults on Broken Three-phase Cables.* **L. Lewin.** (Elektrot. u. Maschinenbau, 26. pp. 210–212, May 5, 1918.)—The position of a fault in a 3-phase cable may be determined when one or more cores are broken, by comparison of the capacity of the individual cores, provided none of them are earthed. But it often happens that at the moment of interruption of the second phase of a 3-phase cable the arc set up melts the copper or chars the insulation so that one or more cores in each of the two portions may be earthed. Several cases are worked out mathematically, the position and size of the fault being calculated. If all the cores in one portion BC are earthed and none in the other half AB, then, as is known, the determination of the position of a fault is achieved by measurements of the capacity of an unearthed core in AB, and comparison of the value obtained with the capacity per km. given on the test sheet of the cable. Since this value varies according to the number of cores earthed, it would be very useful if cable-makers would state on their test sheets all three values of the capacity, *i.e.* C_1 when no cores are earthed, C_2 when one core is earthed, and C_3 when two cores are earthed. V. C.

519. *Lightning Arrester Spark-gaps.* **C. T. Allcutt.** (Am. I. E. E., Proc. 37. pp. 519–540, May, 1918.)—This paper describes a new form of high-voltage lightning arrester gap, which has been called the "impulse protective gap," because of its effectiveness in protecting against line disturbances of steep wave-front. In its elementary form it consists of two gaps in series, each gap being shunted by a relatively high impedance. At line frequency, these impedances are proportional to the respective discharge voltages of the gaps, but they are designed to change at different rates with changes of frequency

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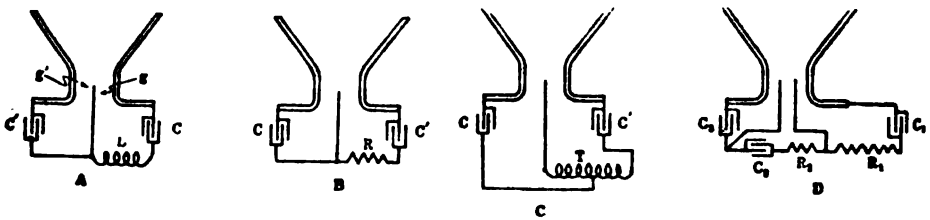
so that under the action of a high-frequency impulse one of the impedances becomes much greater than the other, and causes most of the high-frequency voltage to be impressed on one of the gaps. The breakdown of this gap will result in the total voltage being impressed on the remaining gap, which will break down in turn. It has been found experimentally that a single gap, with an intermediate electrode, gives better results than two gaps. The adjoined drawing gives several such types of construction. *A* shows the auxiliary electrode connected to condensers and an inductance ; *B* has a resistance in place of an inductance, and is commercially preferable, since the inductance must be bulky unless the condensers have an unreasonably high capacity. With *B*, it is possible to get very good results with capacities as low as 10^{-11} farad. With *C*, an auto-transformer is used to displace the voltage, as it were; *D* has two intermediate electrodes : R_1 is greater than R_2 ; the impulse causes the right-hand gap to break down first. For extremely long gaps, it is probable that this is better than *B*, but for commercial voltages it is in general unnecessary. Photographs are given of two forms on which tests were actually carried out : in the one case, the gap consisted of plain horn



electrodes, made of brass rod, 0·95 cm. in diam. ; in the other, brass hemispheres, 6·25 cm. in diam., were clamped to the horns. The methods of testing and the results are given, partly in the form of curves and tables.

It is considered that the "impulse gap" has great possibilities as a protective device, but the action of the gap under more adverse conditions must be studied before its value can be regarded as definitely established. There is the possibility that the gap may exhibit large time-lag when an impulse considerably in excess of its discharge voltage is applied, thus permitting the voltage to rise to a dangerous value before discharge takes place. Tests were carried out on this point, connecting a sphere gap in parallel with an impulse gap under test : but it was found that there was no great likelihood of risk on this point. The tests were mainly carried out at frequencies of 500,000 ∿. The results of the tests show that against steep wave-fronts, the protective gap should have the lowest possible impulse ratio, preferably less than unity : there is need for a protective gap, having selective properties, rendering it sensitive to steep wave-fronts ; this selective device may be constructed without greatly complicating the usual horn-gap structure. The tests are considered to show that the new device is superior to the ordinary sphere gap under all conditions, and even under the most unfavourable conditions it gives a high degree of protection. W. H. S.

520. *Phantom Circuit Remote Control System.* **H. H. Reeves.** (Gen. El. Rev. 20. pp. 884–888, Nov., 1917.)—A description with diagrams and detailed illustrations of a system of control for switching on and off street lights, by d.c. impulse through the a.c. feeders. The street lights are supplied from 2300-volt overhead lines through transformers attached to the transmission poles. The diagrams (see Figs.) show the connections for systems with

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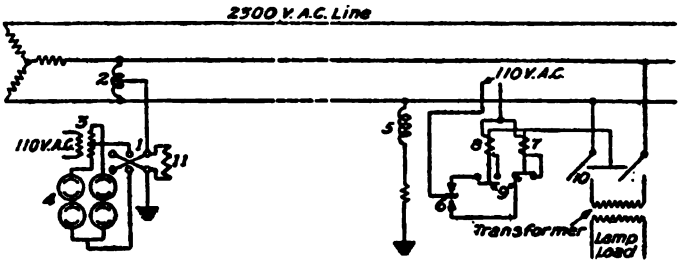
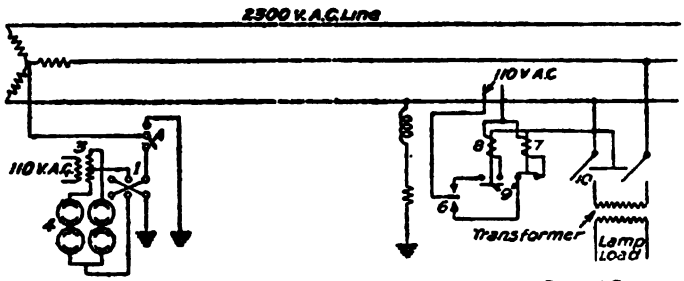
grounded and ungrounded neutral. The d.c. impulse is derived from aluminium cell rectifiers where 125 volts direct current is not available; the earth is used as the return conductor for the impulse circuit and the other conductor is one of the feeder lines on which the d.c. impulse is temporarily superimposed. At the lamp transformer end is a 2300-volt oil-switch actuated by pull-on and pull-off solenoids which are energised alternately, through a polarised relay, from a 110-volt a.c. supply. At the station end the feeder connection is made



Connection Diagram of Phantom Circuit Remote Control System, as applied to an Ungrounded Neutral Line



Connection Diagram of Phantom Circuit Remote Control System as applied to a Grounded Neutral Line

at the centre point of a reactance, to prevent the grounding of the line, where the system is ungrounded. With a grounded system this precaution is not needed.

1. C. O. switch.
2. Line reactance.
3. Transformer for rectifier.
4. Aluminium cell.
5. Relay reactance.
6. Polarised relay.
7. } Oil-switch.
8. } Solenoids.
9. Solenoid contacts.
10. H.T. oil-switch.
11. High resistance for line reactance.

A is a single-pole D.T. switch for connecting direct current to line in grounded system. W. E. W.

521. *Tariffs for Interconnected Three-phase Generating Stations.* **H. Bussmann.** (Elekt. Zeits. 89. pp. 93–94, March 7, and pp. 105–108, March 14, 1918.)—The satisfactory operation of several 3-phase generating stations in supplying a common distribution network depends so closely on adjustment of the power factor that it is desirable to institute a system of payment to each station for the energy supplied from it in a manner that takes account of the wattless power. Such an arrangement, adopted by the Rhenish-Westphalian Electricity Works is described.

The operation of generating stations is hampered by a low power factor,

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not only because of undue loading of the electrical apparatus, but also because satisfactory parallel-running may be jeopardised if the generators are so excited that the power factor drops below certain limits. It is shown by numerical instances that under certain conditions the direction of the flow of energy may be reversed by only small variations in the excitation of the alternators. There is therefore a danger that, if the excitations of the different stations are not regulated in sympathy, reverse-current relays may operate so as to cut out one or more of the stations. This is illustrated by a vector diagram. The conclusion is drawn that correct adjustment of the excitation should be encouraged by the use of a special tariff, such as is adopted on the system referred to. This tariff involves the installation of special wattless-energy meters. In calculating the amounts due to the various stations the difference between the readings of a watt-hour meter and a wattless-energy meter is taken as a basis for determining credits and debits. A differentiation is further made between leading and lagging currents by using two wattless-energy meters connected in opposition with stops to prevent them running backwards, or by using a single meter with two counting trains. If the direction of flow of the energy from a station be reversed, the wattless-energy meters are put out of action, other meters being provided to register the power, if this takes place. A diagram of the particular installation in question shows two watt-hour meters, and four wattless-energy meters provided with two reverse-current relays to separate the wattless energy delivered in either direction and with leading and lagging current.

If A is the number of wattless units to be debited or credited, B the actual number of units, and if N_1 and N_2 are the numbers of wattless-energy units delivered at leading and lagging power factor respectively, then for each station we have $A = N_1 - N_2 - B$, which counts as a credit or debit according to the sign of A. If A is negative, the supplying company is debited with A units at 0·5 pf. per wattless unit and the consuming company is credited with 0·25 pf. for the same number of units. If, however, A is positive, the supplying company is credited with 0·25 pf. per wattless unit and the consuming company is debited with 0·5 pf. The effect of this tariff is carefully examined. The meters reading the leading and lagging wattless-energy are adjusted so that the difference in their readings is equal to the reading of the watt-hour meter when the average energy is supplied at 0·7 power factor.

The special meters are of two possible types. In one there are two armatures each of which can register on one of two counting trains according as the current is leading or lagging. The meters are interconnected through a differential gearing so as to register directly the amounts to be credited or debited. In the other type a single armature is used that records credits and debits on two different counting trains according to its direction of rotation. A. J. M.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

522. *Combined Water-power and Oil-engine Plant.* **A. R. Zahorsky.** (El. Rev., Chicago, 72. pp. 863–864, March 2, 1918.)—Describes briefly an electric power plant supplying a population of about 1000 at Steelville, Mo. Water power is obtained by confining the discharge of a spring a quarter of a mile from the plant and conveying the water round the mountainside in earthen flumes. The effective head is 20 ft.; the discharge rate varies between 8 and 25 cub· ft. per sec. The power-house of reinforced concrete is 16 ft. sq. with 8-in. walls, 12 ft. high, and contains one 15-in. Samson

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horizontal turbine, one 25-h.p. Stoner oil engine, and one G.E. 25-kw. 220-volt 3-phase 60-~ alternator. A 48-in. pulley on the turbine shaft drives the alternator by belt, and another belt connects the turbine shaft to the oil-engine, so that the drive is taken by the turbine or engine, separately or together. The turbine is used for starting the engine, so eliminating the need for a compressed-air system. The generating pressure, 220 volts, is stepped up to 2300 volts for the transmission line which is about a mile long. The line conductors are $\frac{3}{8}$-in. Siemens-Martin 7-strand galvanised steel cables, spaced triangularly 10 ft. apart. The entire distance, 4800 ft., is covered in three spans of 2000, 1000, and 1800 ft. The construction of the line and method of supporting the cable are described, with illustrations.

W. N. Y. K.

523. *Station No. 5, Rochester Railway and Light Co.* **P. B. Findley.** (El. Rev., Chicago, 72. pp. 503–505, March 23, 1918.)—This new station contains two 16,000-h.p. hydroelectric generators, and a third is to be installed. Two falls in the Genesee River, making a head of 180 ft., are utilised at a site within a few feet of the level of Lake Ontario. The Rochester system is a combination of water and steam plants, to which the new station is to supply about 40 % of the total power. The dam and gate arrangements are described. A steel surge tank 60 ft. in diam. × 40 ft. high is fitted above the station. A wave of high pressure forces water up and over the top of a central tube into the tank; when the pressure falls the water flows back slowly into the tube through openings near the bottom of the tank. The vertical riser opens into the horizontal tunnel where it diverges into three steel penstocks 13 ft. in diam., one for each turbine. The two vertical Francis turbines are made by the I. P. Morris Co., and are rated at 16,000 h.p. at 180 revs. per min. with 180 ft. head. The governors, of the double floating-lever type, are oil-operated, either by hand or by remote control from the switchboard. The two generators, 12,500-kv.a. at 0·90 power factor, 3-phase, 60-~, 11,000 volt, star-connected, are by the Westinghouse Co. The entire plant cost about $1,750,000.

W. N. Y. K.

524. *Electric Locomotive for Swiss Mountain Railway.* (El. Rly. J. 51. pp. 805–806, April 27, 1918.)—This locomotive was made for the St. Moritz–Tirano line by Brown, Boveri and Co. The line has an average gradient of 1 in 14, with numerous curves with a minimum radius of 131 ft.: the locomotive has to start trains on the most severe gradients and to maintain a speed of 11 miles/hr., with a max. speed on the level of 30 miles/hr. The locomotive is also used as a snow plough, and for this purpose is operated at very low speeds. Four motors of 155 h.p. each are provided to furnish the necessary torque at low speeds in series. A diagrammatic outline of the construction is given: the motors are mounted in pairs on each truck; each motor is geared to an intermediate shaft through gears with spring-mounted rims to absorb the shocks at starting. The power is transmitted to the driving wheels through connecting rods. The whole weighs 47 tons. W. H. S.

525. *An Electrical Extension on the Pennsylvania Railroad.* (El. Rly. J. 51. pp. 799–803, April 27, 1918.)—This extension is in the neighbourhood of Philadelphia, and runs from Broad Street Station to Paoli, and also to Chestnut Hill. On the newer of these lines, reactance is used instead of resistance to control the current in the motor circuits, which results in a smaller loss during acceleration. A diagram, giving the sequence of switching

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operations, is explained in detail. Tubular construction for the poles, with guys, is becoming the standard method. The transmission wires are of Al, and are carried on cross-arms made of two angle irons, placed back to back, and attached to the poles above the catenary supporting bracket or other structure. Two 44,000-volt transmission lines enter the outdoor substation on a high steel structure, a feature of which is a group of Burke horn-gap switches, which permit complete isolation from the high tension. Full details of particulars are given. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

526. *Greater Uniformity in Track Spirals will Conduce to Economy.* **E. M. T. Ryder.** (El. Rly. J. 51. pp. 649–652, April 6, 1918.)—The author has been interested in working up the proposed uniform track spirals, and in comparing them with the standards of the various steel companies and of the railway companies. Thirteen drawings are reproduced, showing this information. In these proposed spirals the chord length is held uniformly at 5 ft. and the rate of curvature per chord is varied. Each spiral may be used with curves of various centre radii by dropping off the appropriate number of chords from the sharp end of the spiral. The proposed spirals can be laid out on the ground by transit if desired, the deflection angles to all points being given in the data in a table. All the spirals are suitable for easements for plain curves and their number and relative proportions allow considerable variation to suit local conditions. The proposed standards provide three spirals into which 100-ft. switches can be cut, two into which 200-ft. switches can be cut, and one spiral which can be used as an easement for a clearance curve for 200-ft. switches or as a short spiral into which a 75-ft. switch can be cut. Comparative sheets have been worked up for the spirals of four of the large manufacturing companies and three of the electric railway systems. They seem to the author to indicate that the proposed uniform spirals come astonishingly near to being a satisfactory substitute for the various spirals in common use. There are very many instances where the variations from the proposed spirals are less than 6 in. throughout the whole length, and the range from sharp to easy curves is pretty well covered. C. E. A.

ELECTRIC LAMPS AND LIGHTING.

527. *U.S Government Specification and Tests for Glow-lamps.* (El. Rev., Chicago, 72. p. 712, April 27, 1918.)—Revised specifications and tests for glow-lamps, largely drafted by the Bureau of Standards, have been used by the U.S. Government since the outbreak of war. The "useful life" of vacuum lamps is regarded as terminated when the filament breaks or the c.p. drops to 80 % of initial value: for gas-filled lamps 75 % of the initial value is now taken. Mechanical defects are tested by inspection at the factory. Sets of lamps are tested at the Bureau and may be rejected if more than a specified number fail. A table for standard specified rating and life is given, the spherical reduction factor being taken as 78 % for 110–125-volt vacuum lamps and 79 % for 220–250-volt lamps. For both vacuum and gas-filled lamps the useful life is rated at 1000 hours; for vacuum lamps 1·26–1·67 (initial) watts per m. sph. c.p., and for gas-filled lamps 0·70–1·09 watts per m. sph. c.p. (initial) are demanded. The method of testing lamps

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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at the Bureau of Standards is described in detail. The effect of running lamps at excess voltage has been studied. For vacuum lamps the life varies as the 7·4 power or voltage, and for carbon lamps as the 5·88 power. Equations connecting these qualities and also watts per c.p., c.p., watts, and current with voltage are given. Such relations do not apply to gas-filled lamps generally, but can be worked out with appropriate constants for individual lamps. J. S. D.

528. *Data regarding Metal-filament Lamps.* **H. W. Mateer.** (Canad. El. News, 27. pp. 30–31, April 1, 1918.)—The author tabulates information on the latest forms of metal-filament lamps comprising volts, watts, watts per sph. c.p., lumens per watt, total lumens, dimensions, rated life. The vacuum lamps mentioned operate at 1·2–1·67 watts per sph. c.p., the life being rated at 1000 hrs. with ordinary bulbs, and 750 hrs. with round bulbs. Gas-filled lamps operate at 0·78–1·09 watts per sph. c.p., with a rated life of 1000 hrs. The larger sizes can now be made suitable for burning in other than pendent positions. Some particulars are also given of lamps with blue bulbs designed to imitate daylight, operating at 1·12–1·58 watts per sph. c.p. with a rated life of 700 hrs. A diagram is presented illustrating the comparative proportions of red, green, and blue light in the case of the above, and also carbon-filament lamps. J. S. D.

529. *Light Projection with Gas-filled Lamps.* **R. P. Burrows** and **J. T. Caldwell.** (El. World, 71. pp. 766–769, April 13, 1918.)—The aim in projection appliances is to diminish the rear focus of the condenser as much as possible, so as to utilise a large proportion of the flux of light. A limitation is imposed by the thickness of the lens, which increases absorption, is prejudicial to definition owing to increased spherical aberration, and colours the image owing to chromatic aberration. Moreover, rays which strike the lens at an oblique angle tend to be reflected and lost. Brilliancy of the light-source is limited by diminished life of filament. Increase of diameter by increasing possible operating temperature, is favourable to increased brilliancy. The size and shape of filament must be specially designed to enable a maximum of light to be gathered by the condenser. An apparatus is described specially designed to meet these conditions. The "monoplane" filament is arranged in minimum space, with all coils in one plane, and with wire of large diam. Such lamps take 20 amps. at 110 volts and are run at a high efficiency, with an average life of 100 hours. The cost of renewal, on this basis, approaches that of carbons, but there are other advantages. A special Fresnel condenser, adapted to the filament is used and permits 76° of light-flux to be collected. A spherical mirror behind the source serves the double purpose of reflecting rays otherwise lost, increasing the light on the screen by 50–75 %, and filling the interstices between the continuous source. The use of gas-filled lamps also permits of a larger aperture, owing to elimination of arc-flicker. A change from F–2·5 to F–2 doubles the illumination. A satisfactory 12-ft. picture can be projected 90 ft. The illumination is very uniform and steady, and colour-values are good. Booths housing the lamp keep comparatively cool, deposits of dust from the arc on the condenser are avoided and operating expenses are reduced. The lamp is also much easier to manipulate than an arc. J. S. D.

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TELEGRAPHY AND TELEPHONY.

530. *Computing the Speed of Receiving through Submarine Cables. A Universal Method.* **J. Rymer-Jones.** (El. Rev. 82. pp. 556–558, June 14, 1918.)—The relative working of the same cable from day to day is conveniently expressed in e.p.m., while the speed-rate constant when expressed as KR × e.p.m. should correctly express not only the efficiency of that cable, but its efficiency as compared with that of any other cable whose KR × e.p.m. are known.

Therefore, if plotted daily on a curve sheet, the speed-rate constant will correctly indicate at a glance the effective working—*i.e.* to what extent any cable is daily realising the rate of output which its KR permits of when compared with the best-recorded performance of any other long cable, worked under the same conditions.

A considerable error may enter into the numerator of the old speed formula on account of the number of elements (*e*), adopted as representing an average letter for the whole message, really varying greatly in different kinds of messages. This source of error is entirely eliminated by employing the method recommended by the author—*i.e. counting the actual elements in all the letters (or numerals) which occur in the message;* adding a proper number of elements for spaces between letters and words, and reducing these elements to elements per min. If this be done, then any error which arises when reducing elements per min. to letters, or words, per min. will be entirely due to the constant not being suitable.

The author gives some constants for reducing the number of elements per min. into *approximately* the equivalent average (English) words (newspaper or code) of 5, 7, or 10 letters respectively. The elements in these so-called constants are supposed to represent *n* times the average elements per letter in a large number of such *n*-letter words—plus a due allowance for space elements between letters and words; but neither these nor any assumed number of elements for the alternative *standard* words are equally applicable to very short and long messages, to newspaper phraseology, to short and long code words, or to foreign languages. This is, however, a difficulty easily surmounted by the simple expedient of stating the speed in w.p.m., *together with the constant employed,* in order to denominate exactly the divisor used to give those w.p.m. If this be done, then the speed so obtained will still have a very definite meaning for the same cable as an index as to its daily efficiency. Moreover, whatever any cable company may for its own convenience think fit to allot to (*e*); whatever letters (*n*) to the *word*; or whatever the number of words (*w*) dealt with, these need not concern any one else, because he can by means of the constant supplied to him, correctly convert telegraphic speed expressed in w.p.m. into elements per min.—*e.g.*, either as a basis for calculating the KR, or the weights of conductor and dielectric per unit length, required for any projected cable, in order to give a specified speed of equally legible signals —if worked under the same conditions.

The suggestion is that instead of the speed being indefinitely expressed as (*w*) words, of *n* letters, per min., it be given as (*w*) words (constant) elements per min., which will be a very definite statement and universally understood.

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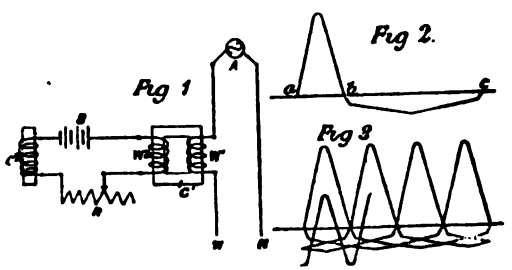
In a pamphlet published in 1911 the authors gave the following constants :—

	Words.	Letters.	e.p.l. (e).	Constants.	
				Ew_1	Ew_2
For 5-letter words, news paragraphs	1200	5670	4·086	32·18	39·18
„ 7 „ „	„	„	„	46·25	53·25
„ 10 „ „	„	„	„	67·36	74·36
For 5-letter words (code words).....	1280	6150	4·877	33·88	40· 8
„ 7 „ „	1256	8792	4·226	47·58	54·58
„ 10 „ „	883	8380	4·139	68·39	75·39

If for siphon recorder, Ew_2 be taken as 40 elements per word of 5 letters, and for Morse recorder Ew_2 be taken as 50 elements per word of 5 letters, } International alphabet
the speed in w.p.m. would thereby be standardised and rendered universally comparable. E. O. W.

531. *Increasing the Frequency of Electric Currents.* (Brit. Pat. No. 112,481. Engineering, 105. p. 445, April 19, 1918. Abstract.)—Describes a method of multiplying the frequency of electric currents. The invention is based on the following principle : If one of the mains from an a.c. source includes a winding upon an iron core in which there are no air-gaps or only small ones,



and which has a second winding in circuit with a d.c. source and a choking coil with an open core, the curves for the current and voltage in the main will possess the peculiarity that the amplitude on one side is much larger than on the other, while that portion of the period corresponding to the larger amplitude is smaller than the portion corresponding to the smaller amplitude, the ratio being a function of the amp.-turns of the two windings. Fig. 1 represents the arrangement. The curves for the current or voltage are of the form shown in Fig. 2. If this arrangement is introduced into the phases of an n-phase supply and the currents are then combined, a current of n times the fundamental results. Fig. 3 illustrates the case of a 4-phase supply. The phases are directly added without the employment of transformers. The arrangement is due to the Marconi Wireless Telegraph Co., Ltd., and I. Schoenberg. H. H. H.

532. *Audibility Factor of a Shunted Telephone.* **G. W. O. Howe.** (Phil. Mag. 35. pp. 487–490, June, 1918.)—The author has previously criticised work on this subject by van der Pol, who replied to Howe's criticism [Abs. 223 (1918)]. Howe now points out that Love had overlooked the fact that in his calculations Austin states that he used the *inductive resistance* of his telephones,

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and not the steady-current resistance. Hogan also used the impedance in his work. Calculation from Austin's results shows a remarkable constancy for the value of the quantity $I^2S/(R + S)$ if the impedance (2000 ohms) is used instead of the steady-current resistance (600 ohms) of the telephones, showing that there is not the slightest foundation for Love's statement that Austin's results do not support the conclusion that the current is proportional to the square root of the audibility factor. It should be noted that Austin's receiver had an inductive resistance $3\frac{1}{3}$ times the steady-current resistance, which is in agreement with the value of this ratio previously given by Howe. It appears that the use of the steady-current resistance, as suggested by van der Pol, has no advantages which would justify its employment instead of the effective impedance of the telephones used. A. W.

533. *Constants of Radio-telegraphic Stations.* M. **Dieckmann.** (Jahrb. d. drahtl. Tele. 12. pp. 506–510, April, 1918.)—At present there is a lack of simple characteristic constants to define the power of sending and receiving stations in wireless telegraphy. The usual method of defining the antenna of a sending station is by the number of watts calculated from the antenna current and antenna resistance. As this does not take any account of the radiating properties of the antenna, it does not lead to a means of calculating the range of the station. In the case of receiving stations only figures of the most general kind are generally given. The author proposes a system of constants that he has devised in a series of experiments with the help of Zeppelin airships.

It is assumed that the sending station emits undamped waves, that the surface of the earth is a good conductor, and that absorption of the energy in its passage between the stations may be neglected. All constants are referred to a definite wave-length, azimuth, and current in the sending antenna.

The "Sending Constant" S is defined as the number of watts that the station sends through a surface of 1 sq. m. perpendicular to the radiation, and r km. distant; this would have different values for different azimuths with directive antennæ, or if the earth had different resistance in different directions.

The "Receiving Constant" E is defined as the area in sq. m. from which the antenna absorbs all the radiated energy. It thus follows that the number of watts γ measured at the receiving station is given by $\gamma = ES/r^2$. According to the sensitiveness of the receiving apparatus there is a lower limit to the power Γ, at which signals are just audible given by $\gamma = n\Gamma$, where n must be greater or equal to unity. If $n = 1$, the energy used is just sufficient for the reception of signals, and the stations are at the greatest permissible distance R apart. This distance is $R\sqrt{(ES/\Gamma)}$ kilometres.

From the number n of receiving units that are measured at a distance r, the max. range of the stations may be calculated from the equation $R = r\sqrt{n}$ kilometres.

If the current I in the receiving antenna is measured instead of the watts, we have $I = K/r$, where $K = \sqrt{(ES/\rho)}$, and ρ is the antenna resistance.

If signals are received from two sending stations the ratio of their sending constants is equal to the ratio of the quantities γr^2 for each of the stations. On the other hand, if two receiving stations measure the power received from a single sending station, the receiving constants of these stations are proportional to the same quantities. Lastly, if two stations are at a variable distance apart, the distance may be calculated from the relations $r_1/r_2 = \sqrt{(\gamma_2/\gamma_1)} = I_2/I_1$.

Corrections are necessary if the waves are damped and if there is absorp-

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tion of the radiation. The damping constant $\beta = \delta_2/(\delta_1 + \delta_2)$, in which $\delta_1 + \delta_2$ are the decrements of the primary and secondary circuits. The absorption constant K is given by $K = e^{-Ar}$, in which $A = a/\lambda$ according to the formula of Cohen, λ being the wave-length. The conclusions stated above will now hold if each sending and receiving constant is divided by the corresponding value of β/K.

It will be noted that the absorption correction for S and E will be very small if the distance between the stations does not vary over wide limits. Stations used for measurements of the nature indicated should supply polar curves showing the value of S for different wave-lengths, antenna currents, and azimuths. Airships afford the best method of producing such diagrams owing to the absence of earth resistance, and to the fact that they can approach the sending station near enough for the absorption correction to become negligible. A. J. M.

534. *Chart for Oscillation Frequency and Wave-length of Oscillatory Circuits.* **P. Luckey.** (Jahrb. d. Drahtl. Tele. 12. pp. 516–518, April, 1918.)—Gives a diagram from which the oscillation frequency and wave-length of an oscillatory circuit of given capacity and self-induction may be found. The chart is based on the logarithmic relation $\log \lambda - k = \frac{1}{2}(\log L + \log C)$. A. W.

535. *Notes on Valve Patents published in* 1917. **I. Schoenberg.** (Year Book of Wireless Telegraphy, pp. 928–951, 1918.)—A critical article in which the actions involved in the arrangements described in some of the more promising specifications are dealt with in an interesting manner. L. H. W.

536. *On the Energy Transmission in Wireless Telegraphy.* **B. van der Pol, Jr.** (Year Book of Wireless Telegraphy, pp. 858–876, 1918.)—A discussion based upon our present knowledge on the subject. The need for further research is emphasised. L. H. W.

537. *The Evolution of the Thermionic Valve.* **R. L. Smith-Rose.** (Inst. El. Eng., J. 56. pp. 258–266, April, 1918. Paper read before the Students' Section.)—Gives a condensed account of the work done by the various investigators in connection with detectors of the ionised gas type. L. H. W.

538. *Graphical Determination of Wave-length from Capacity and Self-induction.* **A. S. M. Sörensen.** (Jahrb. d. Drahtl. Tele. 12. pp. 526–531, April, 1918.)—Describes with the aid of several diagrams a graphical method of obtaining the wave-length given by an oscillatory circuit of known capacity and self-induction. [See Abs. 688 (1913).] A. W.

539. *Edison Storage Batteries for Electronic Valves.* **M. R. Hutchison.** (Inst. Radio Eng., Proc. 6. pp. 149–158, June, 1918.)—Describes, with diagrams, the development of a new type of Edison battery for use in the anode circuit of valves. This is a small 1·25 amp.-hour, 2·56 volt twin cell. Normal discharge lasts several thousand hours. Various assemblies of these cells for 40 and 110 volts, in conjunction with various filament battery sets, also of Edison make, are described in detail, with electrical operating data, weights and dimensions. The 40-volt set, in steel container, is $11\frac{1}{4}$ in. long, $6\frac{1}{8}$ in. wide, and $8\frac{1}{8}$ in. high, the corresponding dimensions of the 110-volt set being $15\frac{1}{2} \times 12\frac{3}{8} \times 8\frac{1}{8}$ in. A. W.

540. *Limit of the Increase in Transmission Range obtained by Loading.* **H. Jordan.** (Elekt. Zeits. 39. pp. 61–62, Feb. 14, 1918.)—By transformation of the expression for the attenuation constant, the influence of the

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coil-loss angle and the dielectric-loss angle on the transmission is brought out. With given coils and dielectric the value of the self-induction for minimum attenuation is determined, giving the max. speech range. The ratio between this and the range of the unloaded cable is the max. improvement factor and is shown to be dependent only on the sum of the coil- and dielectric-loss angles, and independent of the resistance and capacity of the cable.

The case of the open line is then examined in a similar way. In this case it is necessary to separate the added inductance from that inherent in the line. The dielectric-loss angle loses its physical significance since the eakance is due to the insulators. The results for the open line are, however, similar to those for cable.

The article is illustrated by one graph, being otherwise without numerical or experimental values. W. H. G.

541. *The Telephone Transformer.* **S. Sheffard.** (Telephone Engineer, Jan. 17, 1917. Elettricita, No. 1849, pp. 185–190, Dec. 18, 1917. Abstract.)—The author considers the different types of telephone transformers, either for the local battery or the central battery system and gives a diagrammatic explanation of their working. He shows the utility of 1 to 1 transformers for keeping the symmetry on a particular part of the plant, and discusses the problem of the 4-branch transformer employed to avoid the influence of the pulsations of the battery charging current upon the individual lines.

Two types of the 4-branch transformers, differing in the sense of windings and section of iron, are considered. The author appears to favour the type with larger core, though more expensive, as it allows of batteries of larger internal resistance being used, so that the cost, as a whole, works out at less than for the type with smaller core. E. B.

542. *Automatic Telephone Exchange at Leeds.* **J. Hedley.** (Electrician, 81. pp. 84–87, May 31, 1918.)—An article describing the automatic exchange recently opened at Leeds. This is the largest automatic exchange in the United Kingdom and is equipped for 6800 lines. Details of the switching equipment and trunking scheme are given. Trunk calls and calls to other manual exchanges are dealt with by manual operators in the Leeds trunk exchange. Calls from distant sub-exchanges for automatic subscribers are dialled direct by the sub-exchange operators. Outgoing calls from call offices are also dealt with manually, but calls incoming to such numbers are completed over the automatic switches. Among the latest developments embodied are: (*a*) Facilities for cross-connecting subscribers' lines to any line switch. (*b*) If an engaged subscriber be called from the manual board, a "busy" flash signal is transmitted to the operator's cord circuit. (*c*) When a called subscriber replies, the ringing circuit is tripped immediately. (*d*) The trunking can be varied without altering the permanent wiring. (*e*) An alarm circuit is extended to the manual board at night and on Sundays when no engineering staff is on duty in the automatic exchange. (*f*) Standard positive supervision is afforded on calls passing via the manual positions in the trunk exchange.

Six photographs illustrate the article. No circuit diagrams are given.
W. H. G.

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SCIENCE ABSTRACTS

SECTION B.—ELECTRICAL ENGINEERING.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

AUGUST 1918.

PRIME MOVERS.

STEAM PLANT.

543. *Steam Turbine Discs with Shrunk-on Bosses.* **M. Delaporte.** (La Technique Moderne, 10. pp. 126–129, March, 1918. Am. Soc. Mech. Eng., J. 40. pp. 511–514, June, 1918.)—Refers to the conditions under which the last disc of a large-power turbine delivers the desired amount of power when rotating rapidly; the energy represented by the velocity of the steam is a loss (exhaust loss). It is calculated that the last disc of a 15,000-h.p. turbine at 3000 revs. per min. taking 52,500 kg. steam per hour passes 450 m.³ per sec. when expanding into 96 % vacuum. Proportioning of the blades is discussed, and it appears good practice to make the diam. of the last disc from 2 to 2·2 m. The hub would be 1·4 m. in diam., and the load uniformly distributed over the periphery amounts to 750 tons due to centrifugal force. These conditions could not be applied to a single disc forging rotating at 3000 revs. per min., on account of the excessive fatigue which would be produced in the metal. It is suggested that a construction be adopted having collars shrunk on the hub. The calculation of discs of uniform thickness is considered, with investigations of three designs of discs. W. N. Y. K.

544. *By-product Installations for Power Stations.* **Klingenberg.** (Zeits. Vereines Deutsch. Ing. 62. p. 1, Jan. 5, 1918. Elekt. Zeits. 39. pp. 176–177, May 2, 1918.)—The author reviews first the trend of the market for by-products. A great increase in production will cause a fall in prices and, in particular, the price of ammonium sulphate is likely to decrease owing to competition from the numerous nitrogen plants erected during the war, including those working the Haber process. After a brief review of distillation processes (coking and gas-making), the author deals with the erection and operation of plant for gasifying the whole of the fuel and recovering by-products. A gas of high calorific value at low temperature is required, and low temperature is needed in the producer if the tar and ammonia

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compounds are not to be dissociated. One of the most serious obstacles to the design of a large, high-efficiency installation is the limit of 650 to 1080 kw. obtainable from one producer unit, compared with 8000 to 5000 kw. from a steam boiler. The need for auxiliary steam supply is an important factor in the heat balance.

The author investigates in detail the relative economy of three types of power-station plant, namely: steam turbines, with coal-fired boilers; steam turbines with gas-fired boilers and by-product plant; gas engines with by-product plant. In order to cover uncertainties regarding yield and price of by-products, three cases are assumed: (1) 6·44 M. per ton of coal; low yield and low prices. (2) 12 M. per ton of coal; good yield and good prices. (3) 17·56 M. per ton of coal; good yield and very high prices. Other assumptions made are: 1 to 1·5 % nitrogen content of coal; 68 % thereof recovered; 12 % light-load consumption of producer; 70 % full-load efficiency; 50 kg. tar per ton of coal; 2·2 kg. auxiliary steam per ton of coal, 0·8 kg. being raised by producer heat, 1 kg. by exhaust heat in the case of gas engines, and the rest by special boiler. The peak load of the station is assumed to be 100,000 kw. and the size of turbine units 20,800 kw. and of gas engines 6100 kw. each. The latter is relatively a higher limit than the assumed size of the turbine units, yet it involves 22 gas engines as compared with 6 turbines. The heat consumption on full load is taken to be 4360 kg. cals. per kw.-hr. for steam turbines, 3570 kg. cals. for gas engines; and 18 % and 45 % of these figures on light load. Objections to gas engines are: Heavy total first cost; influence of gas composition; expensive attendance, repair and lubrication; vibration of foundations; small overload capacity. Variable load involves increased heat loss and less satisfactory yield of by-products from producer plant. Assuming a load factor of 25 % and the same kw.-hr. output in each case, the coal consumption of a steam turbine plant with coal-fired boilers is exceeded in by-product plant with gas-fired boilers by 150 %, and with gas engines by 40 %. According to this, it is better to burn considerably less coal without by-product recovery than to burn much more coal in recovery plant. At least, no generalisation is possible, and the economic justification for by-product recovery must be established in each particular case.

The capital costs for the three types of plant are estimated to be: Steam turbines without by-product recovery, 22·5 million M.; steam turbines with by-product recovery, 46·2 million M.; gas engines with by-product recovery, 47·6 million M. The capital burden is heavy in cases (2) and (3), but the price of coal is a more important factor with by-product recovery than without it. If the price of by-products below, gas engines are at a disadvantage compared with steam plant, and the lower the revenue from by-products the greater the justification for direct combustion. The author concludes that few by-product installations are economically justifiable where German hard coal (low in nitrogen) is employed. Even with medium nitrogen-content it is unprofitable unless the price of tar and sulphate is well maintained. Steam turbines with by-product recovery are at an advantage compared with gas engines if the price of coal be less than 14 M. per ton. At higher coal prices, and with a by-product revenue of 10 M. per ton of coal, the field of competition of the gas engine is entered, but even then it is necessary to assume a higher load factor than can generally be realised in practice. If the by-product revenue be only 12 M. per ton, the load factor should be 60 %; and if the load factor be only 40 %, the by-product revenue should be 18 M. per ton of coal. Artificial improvement of load factor by chemical or metallurgical loads is

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not to be recommended if the latter could otherwise be served by water power. Direct combustion of coal is advised under any operating conditions if the revenue from by-products is less than 8 M. per ton of coal. The gasification of brown coal offers rather better possibilities than hard coal, particularly as regards the possible recovery of tar, fuel oils, and lubricating oil, but the gross saving anticipated from a quite favourable combination of circumstances does not appear to justify the commitments involved. Neither the amount of coal which could reasonably be subjected to by-product recovery, nor the revenue to be expected from such recovery, is as great as many writers have assumed. R. E. N.

545. *Avoiding Loss due to Soot.* (El. World, 71. pp. 1203–1206, June 8, 1918.)—Compares the efficacy of the hand lance and mechanical blower as means of removing soot from boiler tubes. The lance is simple and its initial cost is small. Two men are required to operate it, and it takes 20 to 30 minutes to do the work on a medium-sized boiler. All the heating surface is not reached, and the soot tends to pile up on the tubes near the wall opposite the lance. The mechanical blower requires one man only, and takes about one-quarter of the time; the initial cost is high, from 5 % to 10 % of the cost of the boiler, and the elements exposed to the hottest gases warp and burn out. Special heat-resisting metal has been used to overcome warping with some success, and corrosion has been reduced by special air valves. Reports on the value of mechanical blowers are given by a number of companies using them. W. N. Y. K.

546. *Economy in the Use of Fuel.* **P. B. Juhnke.** (El. World, 71. p. 1206, June 8, 1918.)—To economise in the use of high-grade coal and in boiler equipment, the Commonwealth Edison Co. in its principal generating stations has fired lower grade fuel during the greater part of the day, and stored the higher grade coal on the floor for use during the peak-load periods. This scheme entailed the objections that large quantities of coal were stored on the floor and extra labour was required to fire it by hand. To obviate these troubles, a scheme was adopted at Fisk Street station to keep high-grade coal in one bunker of every sixteen, the corresponding boiler being banked except during peak load. It may be advisable in future stations to erect auxiliary bunkers for a proportion of higher grade fuel. W. N. Y. K.

547. *Burning Dust-bearing Coal.* **L. A. Stenger.** (El. World, 71. pp. 1080–1081, May 25, 1918.)—Tests were made of the flow of air through coal. The apparatus, like a gasometer, delivers air at constant pressure through a cup with a screened bottom containing the coal under test. The time taken to force a known volume of air through the coal was measured with a stop-watch. Youghiogheny and Illinois coals of various screen grading, dust content and surface wetness were compared. Dust-bearing coal allows about twice the air-flow when wet that it does when dry. Coal referred to as dust is ¼-in. size or less. Good types of forced-draught stokers have their efficiencies reduced by dust-bearing fuels. W. N. Y. K.

548. *Experience with Powdered Coal.* **A. E. MacInnis.** (El. World, 71. pp. 1032–1034, May 18, 1918.)—Gives a *résumé* of experiments made with powdered coal in a 800-h.p. B. and W. boiler which resulted in the Puget Sound Traction Light and Power Co., Seattle, erecting a pulverised-coal plant for 10 boilers aggregating 4100 h.p. The coal is crushed to ¼-in., dried

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in a Ruggles drier, ground in a Raymond mill, transported in a box car with metal-lined hopper and delivered through an enclosed conveyor to the bunker. Lignites may be used coarser than coal. Test results for four grades of coal are tabulated [see table]. The following advantages for pulverised coal are indicated: (1) Different kinds of coal can be prepared and burned by the same equipment; (2) higher efficiency in working; (3) low-grade coals give good results; (4) the fire is easy to control and is smokeless. The company's Western Avenue station coal plant is described. Raw coal is dumped in a 500-ton bunker, and passed through a single-roll crusher at 75 tons per hour reducing it to 1-in. A belt conveyor takes the coal to a 800-ton bunker and an apron conveyor empties the storage into two Fuller driers, each dealing with 15 tons per hour. Dry coal is elevated to a 100-ton bin and thence is fed to four Fuller pulverisers each grinding 5 tons per hour, so that 95 % will pass through a 100-mesh screen, and 85 % through 200-mesh. Air at 6 oz. pressure carries the powdered-coal to the bunkers. The Pacific Coast Coal Co. has powdered-coal plants at Black Diamond and Newcastle Mines. [See Abs. 494 (1917).] W. N. Y. K.

Kind of Coal.	Newcastle (under water many years).	Newcastle.	Mendota Mine Run.	Renton Buckwheat.
	hrs. mins.	hrs. mins.	hrs. mins.	hrs. mins.
Duration of test	14 80	12 80	21 80	14 38
Weight of coal, lbs.	21,220	22,020	22,980	21,820
Evaporation per lb. coal (from and at 212° F.)	8·0	8·77	8·87	8·42
Draught, in. water	0·27	0·35	0·31	0·27
CO_2, %	—	13	13	13·5
B.Th.U. per lb. coal (powdered) dry.....	10,000	11,868	10,985	10,967
B.Th.U., raw coal	8677	—	9952	9449
Efficiency, %	77	75	74	75

W. N. Y. K.

GAS, OIL, AND WATER ENGINES.

549. *High-speed Internal Combustion Engines.* **H. R. Ricardo.** (Engineering, 105. pp. 588–590, May 24; 620–623, May 31, and pp. 650–652, June 7, 1918. Paper read before the N.E. Coast Inst. of Eng. and Shipbuilders, Newcastle-upon-Tyne, April, 1918.)—Compares the development of high- and of low-speed internal combustion engines up to the present time. Town gas and petrol as fuels are compared. The power output of the engine depends on the weight of oxygen that can be taken into the cylinder and burnt in a given time. Three points in favour of petrol are: (1) The volume of vapour required is only just over 2 % as against nearly 17 % for town gas. (2) The latent heat of petrol reduces the temperature of the working fluid; hence a slightly greater weight is taken in for a given volume. (3) After combustion the specific volume of the air-petrol mixture is increased 4 or 5 %; with air-gas it is reduced 8 %. Two disadvantages of petrol are that it is not possible to work (1) with a very weak mixture, on account of the limited range of inflammability, nor (2) with so high a compression pressure, owing to the low temperature of ignition and high proportion of hydrogen. The limiting efficiencies and mean pressures for (*a*) a

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petrol engine, compression ratio 5 : 1 and (*b*) a gas engine, compression ratio 6·25 : 1, are shown in two charts. Consideration is given to the detonation of petrol, mechanical and volumetric efficiencies, and details of design, including a variety of designs for pistons, which are illustrated. Appendices deal with : Mixture strength of petrol, Volumetric efficiency, Detonation, and Working of high-speed engines. W. N. Y. K.

550. *The Heavy-oil Engine.* **C. E. Lucke.** (Eng. Club, Phil., J. 35. pp. 269–279 and 297, June, 1918. Engineering, 106. pp. 127–130, Aug. 2, 1918.)—Notes the lack of development of the heavy-oil engine for commercial purposes in the U.S.A. in spite of the quantity of petroleum available, and of the high efficiency (about 40 %) obtainable. There has been little demand for heavy-oil engines, and petroleum products have been so plentiful that little thought has been given to making the most of them. The fixed charges for oil engines are very high. A change is predicted due to the War, and there are three fields for the increased use of these engines in the near future, namely : (1) Ship propulsion, especially for mercantile purposes ; (2) automobile type of motor ; (3) direct-connected high-speed electric generating sets. The review of ideas is carried out under two heads—functional and structural. In the former category come questions of supply of air and oil, and the proper relationship between them and other processes in the production of power in the cylinder. The structural head includes typical forms and proportions of metal structure that make the machine. The first item under functional processes is that of charging the cylinder with air and is considered in reference to 2- and 4-cycle systems. For the 2-cycle system the ordinary crank-case pre-compression chamber is only suitable for diminutive sizes on account of accessibility of the parts. The step piston and separate pumps for scavenging are considered. Owing to the growth of the number of accessories, it now comes about that the weight per h.p. of the 2-cycle engine is substantially the same as that of the 4-cycle. It is suggested that up to about 200 h.p. maximum the simpler form of 2-cycle engine is most practical, then up to 500 h.p. the 4-cycle is best, and from that upward the 2-cycle system with separate scavenging pumps is best. Combustion is argued in relation to (*a*) the vertical explosive, and (*b*) horizontal non-explosive lines. Constant-pressure non-explosive combustion is only capable of one-half the efficiency of the explosive kind for the same compression. The ignition temperature of the heavy oils is uncertain, but it ranges about 950° F. A table shows the initial temperatures of air from 200° to 600° F. and the compression pressures required to reach ignition temperature and other temperatures above and below it.

Initial Temperature.	Compression, lbs. per sq. in. above atmos. with 0·1 lb. valve drop.							
	Ignition Temp. 950° F.		200 deg. F. below Ignition Temp.		200 deg. F. above Ignition Temp.		400 deg. F. above Ignition Temp.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
200° F.....	190	298	104	152	305	511	467	800
300	110	155	58	79	181	279	282	460
400	67	92	34	42	114	165	175	275
500	41	52	18	22	75	101	118	174
600	23	31	8	10	47	68	79	107

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To produce high efficiency and high power it is clear that there must be not only high compression, but also that the oil must be kept away from the air until the time comes to burn it; *i.e.* late injection is required. The introduction of oil to the cylinder is considered and elaboration of auxiliaries is commented on. W. N. Y. K.

551. *Brake Tests on New High-speed Water Turbine.* J. Reyval. (Rev. Gén. d'Él. 8. pp. 799–808, June 1, 1918.)—Results are given of tests on a new Escher-Wyss turbine which embodies the following special features: (1) High-speed, making possible the direct coupling of electric generators. (2) Guaranteed efficiency of 83 to 84 %. (3) High speed and high efficiency under variable head, the speed remaining constant. (4) Relatively small variations in power under reduced head, and constant speed. The turbine seems particularly suitable for use under very variable conditions. A series of characteristic curves are given for tests under heads of 1·6, 2, and 2·3 m., and with various degrees of opening in the distributor. The turbine realises a max. efficiency of 86 % with 80 % opening and at a speed of 97 r.p.m. on 1 m. head. At full opening the efficiency is 77 % referred to 111 r.p.m. under 1 m. head. The corresponding flow is 1485 litres/sec. and the power 15·65 h.p. (metric). The "specific speed" reduced to 1 m. head is $111\sqrt{15{\cdot}65} = 440$. At minimum and maximum speeds of 77·6 r.p.m. and 126 r.p.m. respectively, the performance is as follows:—(I) *Minimum speed:* full opening; flow = 1330 l./sec. under 1 m. head and efficiency = 76 %; power = 13·5 h.p. and specific speed, = 285. At the same specific speed but half load, the efficiency is 78 %; and max. efficiency at this speed is 83 % at 75 % full load. (II) *Maximum speed*: flow = 1550 l./sec. under 1 m. head; efficiency 77 %; power 15·9 h.p., and specific speed, 508.

The turbine operates at 80 to 85·5 % efficiency between specific speeds of 230 and 485 r.p.m. Between 350 and 400 its efficiency is 85 % or over; and at 550 revs. specific speed, the efficiency is still 74 %. The highest specific speed attained by the new turbine is 610. Notwithstanding its high specific speed, the turbine yields a high efficiency even on partial load; and it is especially recommended for installations utilising low and variable fall. A single vertical-axis wheel of the new pattern may be used in place of several horizontal-axis wheels. About 150 of the new turbines, up to 3000 h.p. per unit, have been installed in France and other countries. R. E. N.

552. *New Regulator for Water Turbines.* L. Barbillion and P. Cayère. (Rev. Gén. d'Él. 8. pp. 747–764, May 25, and pp. 787–796, June 1, 1918.)—The authors discuss in detail the general conditions governing the regulation of water turbines. The regulators used are necessarily of the indirect type provided with servo-motors. Up to the present, the control systems employed utilise more or less directly the principles evolved by Léauté in 1885 in his treatise on the prevention of long-period oscillations in machines driven by water turbines. Léauté concluded that the operation of the servo-motor should be "advanced," so as to damp out the oscillations in question. Various means have been employed to secure this advanced action and the authors discuss typical methods and expose their limitations; in all cases there are more or less considerable oscillations of speed and the regulation is made by successive approximations.

Regulation based on speed as criterion is excellent at first sight, but the results obtained are very bad. For instance, the speed is still too high when the driving torque is reduced to equality with the load; hence the water

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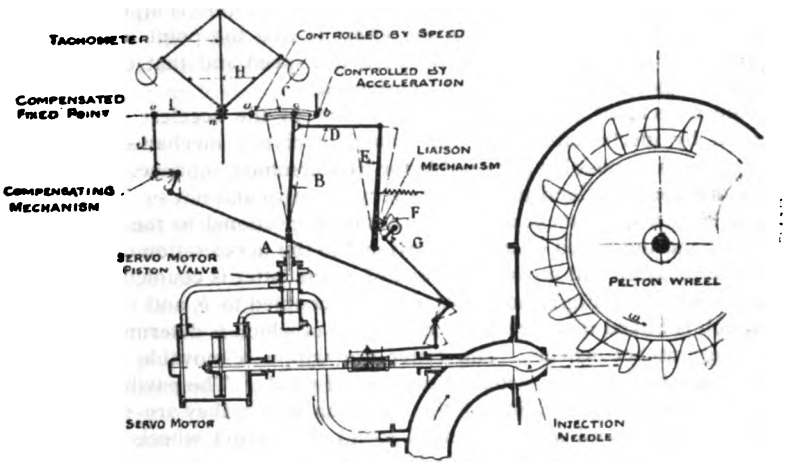
supply is reduced further, and by the time the speed is corrected the driving torque is too low, so that the speed now falls below normal and the distributor must be opened again. By advancing the action of the regulator, this "hunting" can be damped but it cannot be eliminated. In order to prevent the unbalancing of the driving and load torques, the control may be based on the difference in torques, *i.e.* on the acceleration. This means that the water supply is reduced when the speed rises, and increased when the speed falls. Rapid regulation is obtained but the speed is indeterminate, since the controlling factor is the *sense* of the speed variation and not its actual value. Regulation based only on speed produces unsteady torque, and that based only on torque produces unsteady speed. The authors combine the merits and eliminate the defects of both systems by using a mixed system, taking into account both speed and torque differences in order to determine whether the regulator should be opened or closed. If the speed is too high (low) and is increasing (decreasing) there is no doubt that the regulator should be closed (opened). Uncertainty arises when the speed is too high (low) but is decreasing (increasing). Mechanisms sensitive to speed and acceleration are



required and their action must be so combined that the regulator is closed (opened) if the ratio of excess speed is very large (small) compared with the negative acceleration. There is also a certain combination of speed and acceleration such that the speed quickly becomes normal if the regulator be left alone. By considering the characteristics of the driving and resisting torques as a function of speed, the authors show how the compound system of regulation may be designed and rendered most effective. The geometry of a mechanism is analysed which controls a regulating servo-motor by the joint action of detectors of speed error and acceleration. The relative importance attributed to each of these elements is regulated according to the position of the control valve by a law which is studied in detail. The behaviour of the gear is also studied under a variety of distributing conditions. These studies are exceptionally complete and are worth the attention of those closely interested in the subject. The errors of the mechanism and methods of compensating for inertia and friction are also investigated. The principal merits of the new regulator are very rapid action; suppression of speed oscillations; easy adjustment; great sensitivity; strict isochronism; and perfect operation under a complex disturbance.

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The general principles developed in the earlier sections of the paper are applied to the design of a regulator for the following conditions: Max. flow of the fall, 1 m.³/sec.; head, 800 m.; separately excited 12-pole alternator on pure resistance network. Frequency 50·5 cycles light; 50 cycles on ½ load; 49·5 cycles on full load. Max. speed error permissible during a disturbance, ± 10 %; minimum period for complete closing, 10 secs.

The Fig. shows the essential features of a regulator of the new type. The needle valve controlling the water supply is actuated by a servo-motor which in turn is controlled by a piston valve, whose rod A is connected by B to a point *c* in the lever C. The points *a*, *b* in C are displaced by amounts proportional respectively to the speed error and acceleration of the turbo set. A system of levers D, E, G and a cam F ensure that the point *c* takes up a position depending (according to a predetermined law) on the position of the control valve. At the same time the motion of *c* is limited to the circular arc cut in the link C. The movement of *a*, dependent on speed error, is derived from an ordinary tachometer, the sleeve *n* of which operates on the lever I. A compensating mechanism displaces the fixed point *o* of the lever I in order to vary the working speed with load; the design of this compensating gear is discussed in the original. The net effect is that the point *a* is displaced proportionally to the difference between the speed and that corresponding to the admission at the moment considered.

The movement of the point *b*, according to the acceleration, might be secured by inertia effect, but this would involve a mechanism subject to oscillations and possibly responsible for troublesome resonance. The authors therefore use a mechanism which is very sensitive and not subject to oscillations. The displacement of the sleeve *n* is proportional to the speed of the turbine, and the speed of *n* is proportional to the acceleration of the set. In order to measure and utilise the speed of *n*, the latter is coupled to a lever Y (not shown in the Fig.) one end of which is coupled to *b*, and the other end of which is linked to a screw, the rise or fall of which is determined by a nut carrying ratchet wheels. The latter are within a movable guard which determines the effective stroke of two sets of pawls. The pawls are actuated continuously by the rotation of the crank on which they are mounted, and their net effect is nil when the shield round the ratchet wheels is in its mean position. The position of this shield is determined by the movement of the other end of the lever Y. The paper concludes with a further study of the regulator errors, which are unusually small. R. E. N.

553. *Largest High-head Francis Turbine.* (El. Rev. Chicago, 72. pp. 417–418, March 9, 1918.)—The Puget Sound Traction, Light and Power Co., Seattle, Wash., is installing a 25,000-h.p. horizontal Francis turbine at the White River plant where two units of 86,000 h.p. total capacity are already installed. The turbines are all of the same type, horizontal double discharge with spiral case, working at 860 revs. per min. under a head of 440 ft. Steel guide-vanes between which the water passes to the runner are the means for regulating the volume of water. The governor operates the vanes from a steel shifting ring held in three bearings; two steel rods connect the shifting ring to the bell-crank levers actuated by a regulating piston guided by a crosshead. Oil pressure on both sides of the piston is controlled by the governing devices. The capacity of the governor is 50,000 lbs.-ft. and the turbine gates can be moved over their complete stroke in one second.

W. N. Y. K.

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PROPERTIES OF ENGINEERING MATERIALS.

554. *Acid-resisting Ferrosilicons.* **C. Matignon.** (Comptes Rendus, 166. pp. 815–818, May 21, 1918.)—The experiments were made in 1918 with the various ferrosilicons then obtainable, and further with a German ferroboron (69·8 % Fe, 15·4 B, 8·8 Mn, 4·9 Si) and Borchers' metal (64·6 Ni, 32·3 Cr, 1·8 Mo, 0·5 Ag). The ferrosilicons were a métillure of A. Jouve, elianite I and II (the second containing 2·23 Ni), ironac, duriron—all containing from 18 to 17 % Si, less than 1 % Mn; the métillure further contained 2·5 Al. Details of density and corrosion tests are given, the latter lasting up to 358 hours in boiling nitric acid and in boiling mixtures of acetic and butyric acids in equal portions, strong or weak. The ferroboron did not resist acids; the Borchers' metal resisted diluted acid better than concentrated, and differed in this respect from the other alloys, but was not superior to the cheaper ferrosilicons; the elianite II seemed to be less corrodible owing to its nickel contents; the best métillure was a very homogeneous product. None of the alloys resisted hydrochloric acid [see Abs. 667 (1917) and 890 (1918)].
H. B.

555. *The Schoop Metal Spray Process.* **K. Matzinger.** (Elektrot. u. Maschinenbau, Anzeiger, p. 69, April 28, 1918.)—The Schoop pistol is a blow-pipe worked with air at a pressure of 3·5 atmos.; as the pistol operates on the injector principle, however, the "atomising pressure" of the air current which carries the fused metal away was only 1·5 atmos. This atomising pressure has been raised to 2·5 atmos. and higher without increasing the working pressure; and the sprayed lead thus obtained has a very fine grain and is very dense. A lead pipe, 1 mm. wall-thickness, proved gas-tight when filled with hydrogen at 5 atmos. and placed in water, and sheet iron coated with one or two deposits of lead by the improved process did not rust in water, whilst lead pipes and sheet iron prepared by the old process did not pass either test.
H. B.

556. *Use of the Brinell Ball in Testing of Materials of Construction.* **H. le Chatelier and B. Bogitch.** (Comptes Rendus, 166. pp. 840–848, May 27, 1918.)—The application of the Brinell ball test to the measurement of the hardness of ceramic products has hitherto been hindered by the irregularity of the impression produced. This difficulty has been overcome by placing upon the sample a piece of foil $\frac{1}{20}$ mm. thick and 80 mm. square which has been blackened with sulphuretted hydrogen. The impression of the ball is very clearly left on the foil and can be accurately measured. The ball used was 17·5 mm. in diam. under a pressure of 500 kg. left on for 1 minute.
F. C. T.

557. *Ericksen Tests on Aluminium Sheets.* **R. J. Anderson.** (Iron Age, 101. pp. 950–951, April 11, 1918. Am. Soc. Mech. Eng., J. 40. pp. 506–507, June, 1918. Abstract.)—The annealing of 18-gauge aluminium sheets was studied by means of the Ericksen test. The apparatus consists of a holder for the sample and a tool which moves forward until the material is ruptured; the depth of indentation being read directly from a micrometer

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screw. The Al used contained less than 1 % of impurities. The max. softness was attained by annealing at 300° C. for 2 hours. At 200° C. full softening was never attained. At 400° C. an exposure of 5 mins. was sufficient to reduce the scleroscopic hardness to 5. F. C. T.

558. *Potash Resources of South Australia.* D. C. Winterbottom. (Dept. of Chemistry, S. Australia, Bull. No. 2 [84 pp.], 1916. New Zealand J. of Science and Technology, 1. pp. 124–126, March, 1918.)—*Potash from Plants.*—The author concludes from his analyses of sundry garden plants, bracken, etc., that generally speaking the plant life of Australia has a lower potash-content than that of European countries. The following South Australian seaweeds were examined, the figures in brackets being the potash-content of the ash:—(1) *Posidonia australis* (0·6 %), (2) *Macrocystis* kelp (6·0 %), (3) *Ecklonia radiata* (10·0 %), (4) *Seriococcus axillaris* (10·2 %). Samples (3) and (4) contained an appreciable quantity of iodine. (2) is abundant along the rocky coasts of New Zealand, while (3) is common along the shores of the North and South Islands of New Zealand.

Potash from Wool.—The author finds that merino fleece wools do not give the yields of potash reported by earlier Australian authorities, being only 2 to 3 % to cold water. On the other hand, the potash from stained pieces and locks was much higher than from the fleece wools, being from 4·5 to to 6·25 %. The following method is suggested for scouring the wools and recovering the potash. At present the wool is run through the scouring bowls in a scour solution of sodium carbonate, but if it were intended to recover the potash, it would first be necessary to run the wool through an ordinary wash-bowl, or Malard steeping-machine containing tepid water only, without any chemicals. This would dissolve out all the potash and some of the wool-fat. The wool could then be passed to the soda-ash scour solution, while the water-scour, carrying the potash, would be allowed to concentrate, and then be run off to open vats and evaporated down to nearly dryness. The thick "sudorate of potash" would then be transferred to pans and ignited at a red heat, when the organic matter and fat would be burned off, leaving an ash carrying only carbonate of potash with dirt from the wool. The mass could then be extracted with hot water, the liquor decanted or filtered off, and evaporated to dryness, yielding a potassium-carbonate residue of almost the composition shown by the analyses given. This process aims at recovering the potash only, and will probably be subject to some modification when the recovery of wool-fat is also taken into consideration; but even this process would effect the recovery of a considerable portion of wool-fat from some classes of wool. The author gives figures for the erection of a plant for dealing with 8000 tons of greasy wool annually, which shows a profit of £868, assuming that amount of wool to yield 157½ tons of potassium carbonate, worth £17 per ton, after deducting the cost of production, namely £1504.

Potash from Alunite.—Alunite is a mineral from which potash is easily obtained, and if merely ignited the mineral forms a good potash fertiliser. At Bullahdelah, in New South Wales, Australia possesses what has been described as the biggest deposit of alunite in the world, from which shipments have been made to England for many years.

After reviewing these possible sources of potash, the author comes to the conclusion that Australia need not fear a potash famine, and that the most promising sources are the recovery from wool-scouring and from the alunite deposits. J. B. C. K.

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559. *A Self-adjusting Spring Thrust Bearing.* **H. G. Reist.** (Am. Soc. Mech. Eng., J. 40. pp. 893–894, May, 1918.)—Thrust bearings for supporting the heavy loads of water-wheels and the electric generators driven by them, are now very widely used. The difficulties in the fitting and use of plate bearings are much aggravated as the weight is increased, on account of the large overall dimensions of the supporting plate. A typical design of a spring thrust bearing for vertical-shaft machines is described. The bearing consists of a runner of a special grade of cast iron resting on a thin steel ring with a babbitted surface. The babbitted stationary ring, in turn, rests on short helical springs and is held against rotation by dowel pins. A saw-cut through one side eliminates any tendency of the ring to dish with a change in temperature. A high-base ring on which the springs stand is often used in connection with a deep housing to increase the amount of oil in the surrounding bath. A tube in the centre forms a retaining wall around the shaft, for the oil. The springs ordinarily used are wound of ½-in. round wire and have an outside diam. of 2 in. and a free length of 1¼ in. Under load the springs close about 1/16 in. and the total pressure is well distributed. By this means it is possible to avoid excessive pressures at any point. Thus, it is safe to run with a much higher average pressure than when there is no definite limit to the pressure which may occur over a small area. This type of bearing differs from the solid-ring thrust bearing in that one of the bearing surfaces is made to yield at any point by using a comparatively thin plate supported by a large number of springs. While solid bearings may be used successfully for small loads, a bearing which thus automatically adjusts itself to faults in finish and in alignment is preferable for carrying very heavy weights. Oil grooves are provided in one of the members and sometimes in both. In order to ensure proper circulation of the oil for cooling purposes, in the case of bearings operating at low speed it is necessary to have grooves in the rotor. On high speeds these grooves may sometimes be omitted, relying for circulation only on the friction of the rotor on the oil while passing the grooves in the stator. In many cases very satisfactory results have been obtained by placing radial grooves in both the rotating and the stationary surface. It is the author's practice to have different numbers of grooves in the two plates—for instance, six and eight. With grooves in each of the surfaces there is a constant flooding of oil on all the bearing surfaces and a very effective means of cooling. Much of the heat would otherwise have to be transmitted through the metal of the stationary part of the bearing. The pressure usually allowed on these bearings is from 300 to 400 lbs. per sq. in., the design permitting a very thin oil film without metallic contact. It is necessary to have the runner very smooth and free from scratches, especially at an angle to the direction of rotation, as these might cause injury to the babbitt. The babbitted surface does not need to be scraped, but is turned with a tool as smooth as is convenient. Wearing sometimes occurs in minute spots all over the plates. When this happens, there is no risk of dragging the metal. The bright spots that show themselves are produced while starting and slowing down, before a pressure film is formed. When in operation the weight is apparently entirely supported on the oil film. C. E. A.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

560. *Alcohol and Acetic Acid from Carbide and Acetylene.* (Chem.-Techn. Wochenschrift, 28. p. 55. Elekt. Zeits. 89. p. 170, April 25, 1918. Abstract.)—The hydrogenation of acetylene into acetaldehyde $CH_3.COH$ can be effected by the aid of sulphuric acid and mercury salt as catalyst. By passing the aldehyde vapours and hydrogen over finely-divided nickel, alcohol $CH_3.CH_2OH$ is obtained; when the aldehyde is oxidised in air with the aid of nickel as catalyst, acetic acid $CH_3.COOH$ is produced. The Swiss Government granted, in March 1917, a concession for the manufacture of 10,000 tons of alcohol yearly to the Elektrizitätswerk Lonza A.G.; the works are at Visp, in the Rhône valley; the firm has a process of its own. [There are various German patents and the French Pat. 479,656 of H. Dreyfus, who oxidises with the aid of peroxides; the latter's process of preparing acetaldehyde from acetylene at 1·5 atmos. and 25° to 40° C. is described in Brit. Pat. 105,064 of 1917; acetic acid he makes according to Brit. Pats. 105,065 and 108,459, with the aid of various catalysts, Pt, Cu, Fe, Cr, cerium and vanadium oxides.] H. B.

561. *Magnetic Properties of Zinc Blende and Some Other Minerals.* **F. Stutzer, W. Gross,** and **K. Bornemann.** (Metall. u. Erz, 15. 1. pp. 1–9, Jan. 8, 1918. Abstract of F. Stutzer's Dissertation. Elektrot. u. Maschinenbau, 36. p. 228, May 12, 1918. Abstract.)—Researches started in 1914 for the purpose of investigating the possibility of magnetic separation and the state of combination of the iron in minerals. Two equal primary coils were so mounted at right angles to one another that there was no mutual induction; the primaries, on glass tubes, 80 mm. in diam., were joined in series, the secondaries (wound over them) in opposition; on suddenly changing the primary current, the ballistic galvanometer in the secondary circuit gave no deflection. When a piece of iron wire or a magnetic mineral in the shape of powder contained in a thin-walled glass bottle was introduced into the one tube, a deflection was observed; this deflection was, however, very weak with zinc blende. The differential arrangement was therefore improved by inserting an interrupter (at 1200 r.p.m.) into the primary, and by rectifying the resulting secondary alternating current with the aid of a commutator; the deflections were then proportional to the susceptibility. The apparatus was standardised with solution of iron chloride. Of 58 minerals examined some (quartz, calcite, calcium fluorite, lead sulphide) containing up to 0·21 % Fe gave no measureable effect. In others, comprising some light-coloured specimens of blende, pyrite, markasite, with up to 8 % Fe, the susceptibility κ was less than 20×10^{-6}, and these minerals are classed as unmagnetic. Other minerals are distinguished as difficultly or easily magnetisable; some serpentines, ilmenite, franklinite, magnetite, belong to the latter class, the value of κ for one magnetite going up to $97,850 \times 10^{-6}$. The susceptibility varied much in different specimens of the same mineral, of course; the value of κ in some dark-coloured blende was 519×10^{-6}. The chief magnetic constituent of these minerals seems to be iron; further, manganese, nickel, cobalt, and also copper come into ques-

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tion. In an appendix to the paper (*ibid.* pp. 9–10) **G. Hilpert** discusses the reliability of this differential method. As long as the value of κ is below 4000×10^{-6}, the method should be accurate within 1 %, and this is confirmed by the experiments. For higher values of κ the error may (in the case of magnetite) rise to 2 %; by adopting different coil dimensions a higher accuracy might be secured. H. B.

562. *Inductive Circuits in Parallel.* **H. Pécheux.** (Rev. Gén. d'Él. 8. pp. 891–894, June 22, 1918.)—The problem of the equivalent impedance of inductive circuits in parallel is ordinarily solved by methods introducing the square root of negative unity. These methods need care in their use and are not so instructive as direct methods, where every equation has a real physical significance. The author first illustrates this by discussing the equivalent inductance and resistance of two inductive coils in parallel. He constructs the vectorial diagram and then by projecting the vectors on two lines perpendicular to one another, he obtains equations from which the well-known expressions follow by elementary trigonometry and algebra. The problem simplifies very much when the time constants of all the parallel circuits are equal. If we replace any of the choking coils by condensers the problem is still easily solved in the same way. Finally, he gives the complete solution of the problem of the Wheatstone Bridge when the circuits are inductive.

A. R.

563. *Conditions for Equilibrium in a Circuit containing an Inductance and a Condenser.* **H. Görges.** (Elekt. Zeits. 39. pp. 101–105, March 14, 1918.)—If a condenser of suitable capacity be connected in series with an inductance having an iron core, and an alternating voltage be applied across the combination and gradually increased, the current, the voltage across the condenser, and the power taken remain small until a certain degree of magnetisation of the core of the inductance is reached, when a sudden very large increase takes place in these quantities. In a case quoted, for instance, when the main voltage reached 120 volts, the voltage across the condenser suddenly increased from 84 to 415 volts and the power from 70·1 to 428 watts. The main voltage can then be lowered considerably without disturbing the equilibrium until a sudden return to the lower values occurs. In the case quoted the main voltage was lowered to 77·5 volts before this took place. The effect, which is due to the rapid fall in the value of the inductance when the knee of the magnetisation curve is reached, has been studied by Martienssen [Abs. 287 (1910)] and Biermanns [Abs. 986 (1915)], the latter of whom has examined it theoretically. Görges now presents a method of determining the conditions for equilibrium when the magnetisation curve and the curve for the power consumption of the inductance are given. He employs a graphical construction, representing the main voltage by the base of a triangle and plotting from the data the loci of the extremes of the two sides, which represent the voltages across the inductance and condenser respectively. The height of the triangle is proportional to the power consumption. He shows that for a certain range of voltage these loci intersect at two points, yielding closed triangles, corresponding to two different states of stable equilibrium. A third point may occur at which the equilibrium is unstable. When the core of the inductance contains an air-gap only one point is found. Results of measurements are compared with the theoretically determined voltages and agree satisfactorily. W. H. G.

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564. *The Oxide-film Lightning Arrester.* C. Field. (Am. I. E. E., Proc. 37. pp. 541–550, June, 1918. El. World, 71. pp. 1868–1870, June 29, 1918.)—The arrester comprises a film of insulation in contact with a conducting powder. Over-voltage breaks down the insulating film, but the powder is converted to insulation by the heat due to the momentary current-flow. There is thus in effect a self-sealing insulation which permits the flow of lightning discharge but prevents power discharge from following. Lead peroxide is a suitable powder for this type of arrester. The specific resistance of PbO_2 is about 1 ohm per inch-cube; at about 150° C. the PbO_2 is reduced to Pb_3O_4 which has a specific resistance of about 24×10^6 ohms per inch-cube; and at slightly higher temperature the reduction is continued to PbO, which is practically an insulator. Bismuth oxides give similar results.

The commercial form of the oxide-film arrester comprises two sheet metal electrodes covered with a thin insulating film. The plates are set $\frac{1}{8}$ in. apart and the space between them is filled with lead peroxide. Up to a pressure of 800 volts or so per cell, the leakage current is only a few milliamps. When the limiting voltage is reached the film breaks down (more suddenly than the hydroxide film of an aluminium arrester), and the lightning charge flows to earth, meeting with practically no resistance in the arrester. Dynamic current starts to follow, but the current density through the film perforations is so high that the conducting powder immediately adjacent is converted almost instantaneously to a plug of insulation. This action occurs in less than $\frac{1}{10000}$ sec. after the lightning discharge ceases. Various methods are described for preparing the insulating film on the electrodes; probably the best method is to dip burnished brass, steel, or copper in varnish or lacquer.

The action of the arrester is amply rapid enough to relieve the abnormal electric pressure before damage is done to the insulation. The main gap in series with the cells is a sphere gap, which has the fastest spark of any practical gap. The equivalent sphere gap of the insulating film is several times the thickness of the latter but is still low. The series resistance of the peroxide in the path of flow does not give an undesirable voltage drop, and the inductance of the arrester is a minimum. One of the principal difficulties with this type of arrester was the increase in resistance after a number of discharges; probably this is due to air in the insterstices being heated by discharges and thus causing "fluffiness" or poor contact between the particles of powder. Violent jarring or compression reduces the resistance again, but increased thickness of the insulating film gradually assumes importance. Normally the power factor of the arrester is near unity, but by mixing a proportion of non-conducting powder with the conducting powder, any power-factor down to 10 % can be obtained. This is often useful in condensers, but is not desirable in the arrester. The diameter of the punctures in the insulating films is about 0·005 in. and the heat conductivity of the powder is so low that little more powder is reduced than is needed to seal the punctures. The general characteristics of the oxide-film arrester are very similar to those of the standard Al electrolytic arrester, but the former uses no electrolyte and needs very little attention. Notes are given on the testing of the oxide-film arrester and oscillograms show its efficacy.

R. E. N.

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GENERATORS, MOTORS, AND TRANSFORMERS.

565. *Regulation of A.C. Commutator Machines by Direct Current.* **M. Osnos.** (Elekt. Zeits. 39. pp. 205–207, May 23; 215–218, May 30, and pp. 224–227, June 6, 1918.)—Under the term "regulation" the author understands control of the speed of motors and of the voltage and frequency of generators, and any other methods of regulation designed for adjusting the commutation and power factor of commutator machines. The methods described are all based on the regulation of the permeability of the machines themselves or of apparatus external to the machines, by superposing direct current on the alternating currents flowing. The d.c. energy required is very small compared to that of the regulated machine and the control is extremely simple, as it depends on the use of an ordinary regulating resistance. This regulating resistance may even be dispensed with if the voltage of the exciting machine is regulated by brush shifting. By directly coupling the exciter an automatic regulation of a motor to nearly constant speed may be effected. A number of different applications of the method are described in detail and tests on large sets are given.

The principle of the methods may be understood from one of the cases referred to, consisting of a four-pole commutator machine in which the windings of the four poles are connected to form the four arms of a bridge fed across one diagonal by alternating current passing through the armature, and across the other diagonal by direct current through a regulating resistance. The connections are such that the alternating current produces a four-pole field while the direct current produces a two-pole field that has no inducing effect on the four-pole armature. The superposed d.c. field alters the saturation of the machine so that the a.c. field is weakened. If the machine has a number of poles not divisible by four, some of the field windings may be connected as described above and the remaining ones inserted outside the bridge. In the case of polyphase machines various devices are shown by which the d.c. field may be superposed on the a.c. field in a non-inducing manner. The method must be modified for application to shunt machines, as variation of the permeability would not alter the flux, but would merely change the value of the magnetising current. In such cases reactive coils may be connected in series with the field windings, these coils being regulated by direct current. After describing a number of methods for connecting such reactive coils into circuit, details are given of their design.

The principle of all these devices consists in the association of a number of magnetic circuits in an arrangement such that the fluxes set up by the a.c. windings are non-inductive (at least so far as the fundamental frequency is concerned) with reference to the d.c. windings. This is effected by connecting the d.c. windings in opposition as regards the a.c. fluxes. Nevertheless currents of double frequency would be induced in the d.c. windings according to the well-known frequency-doubler effect. These double-frequency currents may be shunted through a resistance across the d.c. windings. Instead of having a number of separate coils to form each reactive unit the various magnetic circuits may be associated to form one unit, a single d.c. coil being linked with several magnetic circuits, each of which carries an a.c. coil. The different portions of the

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magnetic circuits common to the d.c. windings must, however, be separated by non-magnetic material, so that the a.c. fluxes of the separate branches may not amalgamate. In the case of a three-phase system it is possible to form the reactive coil on a single magnetic circuit with six cores with common yokes.

The tests given refer to: (1) The speed regulation of a railway motor of 600 kw. capacity; the torque and output of this motor can be varied at constant speed by about 87 % with a consumption of only 800 watts direct current. (2) The field regulation of a three-phase motor; the tests show that the voltage on the motor can be reduced to 1/15·5 times the line voltage by connecting a d.c. control choking coil in series with it. (3) The speed regulation of a three-phase commutator motor of 40 h.p. (4) A test on a three-phase motor with direct-coupled exciter controlling the choking coil; these tests show that almost constant speed is obtainable at different loads. (5) The self-regulation of speed for appliances such as spinning machines. It is shown that in the case of a certain motor that dropped 24 % in speed at a certain load, the variation of speed was only 8 % when regulated in the manner described.

The choking coils may be either directly connected to the brushes of the armature of the motor or indirectly through a transformer, and a number of methods of varying the mode of connection are examined in turn. A. J. M.

566. *Design of Large Dynamos.* **M. Vidmar.** (Elektrot. u. Maschinenbau, 36. pp. 149–155, March 31, 1918.)—The article investigates the changes in the dimensions of dynamos required to obtain increased capacity. On the assumption that in a series of machines the electromagnetic loading remains unchanged a number of laws are deduced for the dependence of the dimensions on the output. It is not possible to design machines for increased outputs by simple changes of linear dimensions, as would appear to be the case if the output coefficient were really a constant. As a matter of fact this coefficient decreases with increase of output if the speed remains the same.

The output of a series of geometrically similar machines would be proportional to the fourth power of the linear dimensions. As the weight only increases with the third power of the linear dimensions it follows that the price per kw. must decrease the larger the machine is designed. It would thus appear that the linear dimensions in a series of machines increase with the fourth root of the output.

Machines designed according to this law would, however, be impracticable, as difficulties would be met in the insulation of the wires and slots, and on this account the voltage of the machines must be changed as the output is increased. It is argued that the voltage should increase according to the fourth root of the output. Comparison with practice bears this out. For instance, small transformers of about 10 kv.a. capacity can be built for 10,000 volts. The above-mentioned law would lead to a voltage of 56,000 volts for transformers of 10,000 kv.a. capacity, which is quite in accordance with the present practice. The increase of voltage with the capacity of the machine leads to difficulties, both in the size of the slots and in the insulation of the wires, which become increasingly difficult. Furthermore, the heating in the slots increases with the third power of the linear dimensions, whilst the surface of the coils only increases with the square of the linear dimensions. On this account, in order to avoid heating, the number of slots must be increased with the size of the machine. It is calculated that the number of slots in a series of machines should increase with the eighth root of the out-

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put. If designed according to the methods outlined the losses will increase with the ¾ power of the output, the ohmic drop will decrease with the fourth root of the output, and the percentage magnetising current will decrease with the fourth root of the power.

It is interesting to note that the heat-radiating capacity improves with increase in the size of the machine, as the parts in which the heat is generated are concentrated around the air-gap where it can be carried off by the vigorous air draught, which improves as the machines become larger. It appears that the design of very large units will be determined mainly by heating considerations. A. J. M.

567. *Sudden Short-circuits of Alternators.* **N. S. Diamant.** (El. World, 71. pp. 1028–1031, May 18, 1918.)—The electromagnetic actions that take place when an alternator is suddenly short-circuited are examined more from the physical than the mathematical point of view.

When a machine running on load is suddenly short-circuited, the flux linked with the armature dies down, owing to the strong demagnetising ampere-turns of the armature, to a value depending on the sustained short-circuit current and the field m.m.f. It is assumed that the dying down of the field takes place according to an exponential law, and this law is expressed in symbols. This case has been worked out by P. Boucherot with the aid of rather formidable mathematics, from which he concludes that the presence of amortisseur windings increases the damping factor of the armature about 88 % and that of the field about 16 %. Nevertheless the test results of C. M. Davis indicate that the amortisseur windings have little or no influence. Other tests, however, bear out the conclusions of Boucherot.

The values of the damping factors for the field and armature may be obtained experimentally by measuring the rise of direct current in the field and armature respectively, and from these values the transient armature and field currents on sudden short-circuit may be deduced. The equations for effecting this are given, and they are critically analysed. Their application to particular cases shows that the damping factors are considerably and consistently higher during the first cycle or so of the sudden short-circuit than toward the end of it.

An argument from the equations given shows that, if all the interactions between the field and armature are taken into account, decaying currents of higher frequencies than the fundamental are induced, giving even harmonics in the armature and odd harmonics in the field. Besides these harmonics due to the armature current it can be shown that unbalanced three-phase currents produce on sudden short-circuit armature reactions of double, quadruple, sextuple, etc., frequency, which in turn will produce e.m.f.'s and currents of triple, quintuple, septuple, etc., frequency in the armature.

A. J. M.

568. *Current Distribution in Polyphase Commutator Armatures.* **T. Schmitz.** (Elekt. Zeits. 89. pp. 163–167, April 25, 1918.)—Investigations are made of the distribution of current in polyphase commutator armatures for simple and double sets of brushes. It appears that with the double set of brushes there are in general two groups of conductors carrying different currents. Formulæ are given to calculate the currents in the conductors in terms of the current supply to the brushes, and the space distribution of the two groups of conductors is determined. The latter depends on the angle between the brushes, and differs for the cases of an even or odd number of

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phases. Expressions are also obtained for the reactance voltage of the armature. The results obtained are applied to several examples and collected in tables.

The armature of a 3-phase series commutator motor is generally fed from a 3-phase supply by means of three brushes at 120°. In the case of the machine with a double set of brushes the current is removed from the armature through the second set of three brushes also mounted at 120°. It is possible to transform the 3-phase supply to a 9- or 12-phase supply by means of transformers connected between the 3-phase supply and the armature, and this has the advantage of reducing the commutation voltage.

In the case of the machine with double brush sets the windings connected between the different pairs of brushes overlap, and it is shown that the current in any particular conductor is equal to the resultant of the brush currents of the phases that overlap that conductor. As the various points of the armature are overlapped by different numbers of phases it follows that the currents in different armature conductors will differ. There are two possible values of this current according as the conductor in question is overlapped by two phases or by one. Expressions are obtained for the values of these currents in terms of the angles between the brushes and the number of phases.

In the case of a polyphase rotor with diametrical winding, the superposed conductors will both carry one or other of these currents, or the first may carry one of the currents and the second the other. These cases occur according as the number of phases is even or odd. The tables are drawn up to show the values of the currents in different conductors in armatures with various numbers of phases and with various brush angles and values are also given for the resultant number of ampere-conductors between the brushes of one phase. A. J. M.

569. *Current Distribution in Three-phase Commutator Armatures.* M. Ernst. (Elekt. Zeits. 39. pp. 181–184, May 9, 1918.)—The heat generated in a 3-phase commutator armature with 6 brush studs is zero with the brushes in the no-load position. If half of the brushes are shifted, the copper losses increase. Diagrams are drawn showing how the currents in the different armature conductors vary as the brushes are shifted, and it is shown that if the current supply is constant, the copper losses increase proportionally to the displacement of the brushes until this becomes 120°; from here onwards the copper losses remain constant until the short-circuit position is reached.

The first investigation refers to diametrical windings and the second to chord windings. Practical conclusions are drawn as to the best position for the brushes for normal running. They are usually set at an angle of 120°. This is just the point at which the copper losses begin to decrease with decrease of the brush angle, and it might be considered desirable to work with smaller brush angles in consequence. It must, however, be remembered that as the angle is decreased the power factor is diminished. On the other hand, the angle might be increased without augmenting the copper losses, but an increase of the angle above 120° has the effect of diminishing the overload capacity of a motor at a given speed. A. J. M.

570. *Generator for Impulse Currents.* (German Pat. No. 299,829. Elektrot. u. Maschinenbau, 36. p. 236, May 19, 1918. Abstract.)—Referring

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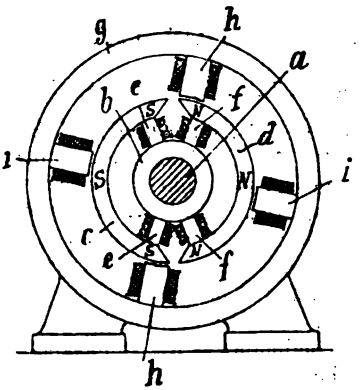
to the Fig., the armature *b* mounted on the shaft *a* has two pole-shoes, *c*, *d*, which nearly surround the armature, their pointed ends being close to



each other. The cores *e*, *f* carry exciting coils and *hh*, *ii* are cores for the windings subject to induction. Each of these windings feeds a special circuit. The impulse current obtained is symmetrical if direct current be used for excitation, but not if alternating current be used. The arrangement is due to M. Breslauer. R. E. N.

571. *Standard Shaft Ends for Electric Motors.* (Rev. Gén. d'Él. 3. pp. 857–858, June 15, 1918.)—P. Lecler criticises the standardisation recommendations made by the Comité technique de la Chambre syndicale des Constructeurs de gros matérial électrique [Abs. 356 (1918)]. The secretary's replies are given. The drawing in the previous communication should have shown a total taper of 1/10, *i.e.* a slope of 5 %. Reasons which appear to be adequate are advanced against Lecler's suggestions for further standardisation of keys, etc. As regards his suggestion that pulleys be standardised, particularly in the smaller diameters, the Committee state that they are now engaged in standardising belt speeds. Owing to the great diversity in motor speeds, it is not practicable to standardise pulley diameters. R. E. N.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

572. *Energy Losses in High-tension Lines.* **F. Hoppe.** (Elekt. Zeits. 89. pp. 153–155, April 18, 1918.)—The present necessity for economising materials renders it necessary to permit greater energy loss in lines, notwithstanding the loss in commercial economy. Limitations will mainly be set by the permissible voltage drop and the magnitude of the corona losses.

The investigations have the object of determining what percentage energy losses should be allowed in transmissions. Conductors are calculated for a definite max. load. This sets a lower limit to the section of the wire, if the heating of the conductors is not to become excessive; sufficient tensile strength should be allowed and the corona losses should not become too great. Also, an upper limit to the section of overhead wires is set by the practical difficulty of suspending wires above a given section. The greatest possible sections are 120 to 150 mm.² for copper or iron and 240 to 310 mm.² for aluminium.

The section q obtained for a given percentage energy loss p at a load W kilowatts is given for a 3-phase line by $q = sLW \times 10^5/pE^2\cos^2\phi$, in which s is the specific resistance, E the transmission voltage, L the distance of transmission in metres, and cos ϕ the power factor.

In order to determine the value to be given to p it is necessary to examine the connection between the max. load, the annual load, and the annual losses. This is carried out with the aid of a series of typical load diagrams drawn for the various seasons of the year. In each diagram both the output and the losses are given. Averaging over the whole year the mean load is found to be 37 % of the max. load. If x is the max. load in kilowatts, and the losses at max. load are $px/100$, the annual output in 8760 hours is $8760 \times 37 \times x/100$ and the annual losses $8760 \times 17 \times px/10000$, and the ratio between the annual losses and the annual output becomes $0{\cdot}0046p$. The conditions under which the above calculations are made are very unfavourable, and it thus appears that the figure for the annual losses in the most unfavourable case is about half the percentage p that has been taken in the calculation of the section. A calculation of a special case is made by the methods described, and it is shown that if 2000 kw. are to be transmitted over 50 km. at a power factor 0·85 with a 40,000 volt 3-phase transmission, then if p is taken as 5 % the calculated section is 85 mm.². If the section were taken at 16 m.² the value of p would be 11 %. The saving in copper would be 25,000 kg., obtained at the cost of an increase of energy of 180,000 kw.-hrs.

In many cases in which a transmission is required over not too great distances a saving of material can be effected by using cables instead of overhead wires, as smaller sections are then permissible. A. J. M.

573. *Special Transmission-line Problems.* (El. World, 71. pp. 919–922, May 4, 1918.)—Details are given concerning novel constructions employed on the Pacific Coast to overcome difficulties peculiar to supporting long spans, Topographical conditions on the Pacific Coast necessitate many long spans, on some of which lofty towers are needed because the span is over water or

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level ground. Some of the special problems encountered are the liability of conductors to swing into contact with each other; the whipping action produced by gusts of wind; the great stresses which have to be transmitted through insulators to the posts; and the abnormal strain on towers when a long span breaks.

The risk of conductors swinging together is generally reduced by one or more of the following methods: Spacing conductors liberally; using conductors which are heavy compared with their exposed area: using intermediate spacing structures; working with small sag; artificially weighting conductors. Reduced sag necessitates increased strength in conductors; special composite or all-steel conductors may be employed.

It is very important to allow for thermal expansion and contraction on long span lines; one way is to hang concrete weights from steel cables running over pulleys and attached to the tower end of strain insulators. In transmitting conductor stresses to the supports care is needed to avoid bending stresses on pin insulators and to distribute the load uniformly between the latter. A single string of disc insulators is not safe above 1500 ft. span. Equalising yokes are desirable to distribute the pull equally between several strings of insulators. In very dry climates surface leakage chars or burns wooden poles and cross-arms.

In two long spans of 453 ft. and 4088 ft. respectively, the conductors are of ¾-in., 19 strand copper-clad steel, placed 20 ft. apart; to prevent contact by swinging, a spacing tower is placed at mid-span on a lower grade than the terminal towers, so that it supports only a fraction of the weight. The San Diego Co. recognises three ranges of span, viz. 1000 to 1500 ft.; 1500 to 2500 ft.; and 2500 ft. upwards. For these there are used respectively: Two pole structures without cross bracing; the same, with cross bracing; and three pole structures for the longest spans. Seven-strand, extra galvanised steel conductors are used for all voltages. At the towers, the conductors are generally bent round a cast-iron pulley and held by guy clamps. Only one type of insulator is used, the number used varying from a single one up to four parallel strings with 5 insulators in each. Other details and photographs of structures used on various lines are given in the original. R. E. N.

574. *Design of Economical Power Circuits.* **P. O. Reyneau.** (El. World, 71. pp. 1072–1073, May 25, 1918.)—In a previous article [Abs. 128 (1918)] the author has considered the economical sizes of feeders for a load consisting of residential and shop lighting with single-phase cables uniformly loaded. The same general method is now applied to the case of 3-phase circuits carrying power load, and a very small amount of lighting. Certain rates of depreciation and interest are assumed, and the results of the calculations are exhibited in series of curves giving for six sizes of wire the ratio of the cost per lb. of copper to the energy cost per kw.-hr. as a function of the max. load in amps. and also as a function of the annual line losses.

A. J. M.

575. *Abac for Calculating Alternating-current Networks.* **A. Castex.** (Rev. Gén. d'Él. 3. pp. 821–823, June 8, 1918.)—The calculation of a.c. networks is simplified by means of an abac from which the reactive power can be read off if the actual power and the power factor are known, or the actual power may be read off if the apparent power and the power factor are known. In this manner the rectangular components of the power can be easily separated out for each branch of the circuit, and these components

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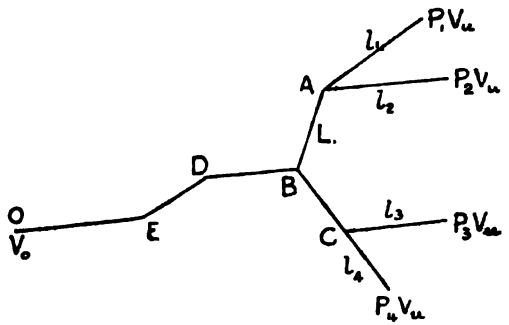
may then be added together separately and recombined to find the total power. The method is illustrated by application to some special cases. A. J. M.

576. *Calculating Network Conductor Sizes.* **Jacques.** (Rev. Gén. d'Él. 8. p. 935, June 29, 1918.)—The author recommends the following method for the rapid calculation of electric networks. It is applicable to any network of however many branches, and it leads to minimum weight of copper in aerial lines.

The lengths and loads of the various sections of the network are known, and in order to determine the section of conductors it remains to find the pressure drop per unit length. Referring to the Fig., if V_0 be the initial voltage, V_u the minimum voltage of utilisation, and D_1 the



distance from the origin to the most distant point in the network; and if P_1 were the only point of utilisation, the pressure drop per metre $= e_1 = (V_0 - V_u)/D_1$. Proceeding from P_1 towards the origin, A is the first bifurcation. The pressure drop is e volts per m. for the line AP_1; thence the section may be calculated and the nearest commercial size adopted. Then $V_A = V_u + el_1$. If a larger section is needed to satisfy heating conditions, the drop from A to P_1 must be recalculated and a new value obtained for V_A. The pressure drop per m. along the branch AP_2 will be $(V - V_0)/l_2$. The section AB of the line is next considered and so on, taking successively the branching points and the secondary networks. R. E. N.

577. *Electric Surges in Transformer Coils.* **W. Rogowski.** (Archiv f. Elektrot. 6. pp. 265–300, 1918. From the Physikal-Techn. Reichsanstalt.)—The mathematical calculation of the voltage-rise in coils caused by surges entering them from a transmission line is one of considerable difficulty. In the present article the author considers the somewhat simple case of a coil consisting of two turns. He promises that at a later date he will extend the theory to a coil of three turns, for which case the mathematics becomes very much more complicated.

The coil with two turns is supposed to be suddenly applied to a steady voltage and is assumed to have the shape of a long rectangle. All the distributed capacity and inductance is assumed to be concentrated in the long sides of the rectangle, and the short ends are considered to have no resistance, reactance, or capacity. The coil with two turns thus becomes equivalent to two pairs of straight conductors pushed into one another. Each pair is first treated separately, and the mathematical modifications involved when they are pushed into each other so as to react mutually are applied to the equations obtained for the case when they are separated.

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It is shown that the coil acts at the first moment like a cable, and the current surges into those conductors that are directly connected with the source. At the same time opposing currents are induced in the neighbouring conductors. The impressed and induced currents meet at the back of the coil, and the heaping of electricity at that part causes the voltage to rise. The shock causes the coil to oscillate, and the voltage-rise is repeated after certain intervals of time until it is damped out by the resistance of the conductors.

It is curious to note that the rise of voltage is independent of the distance between the two turns. This results from the fact that if the coils are close together the capacity is considerable, the initial current is high, and in consequence a large quantity of electricity is accumulated at the back of the coil. If the turns are spaced at a greater distance, the capacity is reduced, the initial current decreases and also the quantity of electricity that is piled up. As the ratio of the quantity of electricity to the capacity of the winding determines the rise of voltage, this remains unchanged.

The mathematics is extended to the case of a coil in which resistance is connected in series with each connection to the line, and the variations of voltage at different parts of the coil are calculated and shown in a series of diagrams.

It is then shown that the assumption according to which all the impedance of the conductors is concentrated in the long sides of the rectangle has very small effect on the result, the actual facts being very closely obtained if the length of the side is replaced in the formulæ by half the perimeter of the coil.

The case is next considered of a coil of two turns, connected to the supply by an overhead transmission line or by a cable. In the first instance it is shown that a surge striking the coil causes an initial decrease of voltage instead of an increase of voltage.

The danger to the coil appears to depend greatly on the length of the transmission line connected to the coil, and the most distant point of the coil is exposed to the greatest stresses. If the line is short, the rise of voltage is independent of the distance between the turns of the coil, whereas if the line is long the voltage increases greatly with the length of the line. With short lines the oscillations are damped by the resistance of the coil alone, but with long lines the line also has a damping action. The max. voltage across the turns does not exceed the impressed voltage with a short line, but may reach twice the impressed voltage with a long line. With a short line it does not matter much whether the line is a cable or an overhead wire, but with a long line a coil might be endangered if the line is a cable, while no danger would exist if the line were an overhead one. It may therefore be dangerous in some cases to replace overhead lines by cables.

In a few words referring to the coil with many turns it is indicated that the danger-point in a coil of one layer lies near the middle in the case of a flat coil, and near the ends in the case of a long coil. A. J. M.

578. *The Best Position for Power Stations.* **D. C. Ashmead.** (Power, 47. pp. 661–664, May 7, 1918.)—The author considers that one of the main difficulties of many central stations arises from the fact that the railways are unable properly to deal with the transport of coal. This is due partly to lack of motive power, partly to shortage of cars, and partly to delay in unloading cars. All this would be avoided if the country were divided into districts, and each district were supplied with power from central stations situated in

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a coal area. A plan is given of the United States of America, showing the positions of suitable sites from which power might be distributed. Various tables are also given, giving particulars as to the 28 districts into which the States would be divided on the author's plan. Approximately 100,000 miles of transmission lines would be required. The cost, which is given in general outline, would be immense, but it is considered that the capital outlay would result in such vast economies that the scheme would be financially successful. The lengths of the transmission lines in the various districts are stated, as also the kw.-hrs. generated by steam in them, and their coal and coke production. Particular cases of successful transmission of power are adduced as evidence of the likelihood of the present proposals being equally profitable. A low grade of coal might be found to be perfectly suitable for the generation of power on a large scale under certain conditions. W. H. S.

579. *Electroculture.* **I. Jörgensen.** (Electrician, 81. pp. 122–124, June 14, 1918.)—The possibility of electroculture assuming greater practical importance is bound up with the development of intensive methods of cultivation in general and the use of electricity for power and lighting in rural areas. The relatively slow progress made in electroculture is due to investigators neglecting the experience of predecessors, and underestimating difficulties. The author discusses laws and principles relating to overhead networks for electroculture. In order to obtain experimental control the system must be investigated as a whole. The system consists of metal-air-plant-earth, and results are affected by diameter and height of wires, potential to which they are charged, atmospheric conditions, kind of plant, and stage of growth.

Lemstrom used a network about 0·5 m. above the growing crop and aimed at constant discharge by keeping this distance constant. The Agricultural Electric Discharge Co. (A.E.D.) uses a network about 5 m. above the ground, charged positively by intermittent rectified current at 50,000 to 70,000 volts. Both systems use parallel wires of 24 S.W.G., 1 m. apart (Lemstrom) or 10 to 30 m. apart (A.E.D.). The author bases an analytical investigation on Townsend's formulæ for the potential required to maintain current between coaxial cylinders. The max. discharge current in certain field tests was about 1 milliamp. per acre, or 10^{-8} amp. per cm. of discharge wire. A cause of uncertainty is the influence of neighbouring wires. There is no difficulty in finding a 24 S.W.G. wire of material strong enough for the spans needed ; but 30 S.W.G. wire is outside the limits of practical application. A great increase in voltage is needed to maintain even 10^{-7} amp. per cm. when wires are a considerable distance from the ground. The alternatives are either to use a discharge network near the ground and work at moderately low voltages, or to construct apparatus capable of yielding very high voltage so that the network may be high above ground. Apart from the difficulty of eliminating leakage over insulators, the results from a given network vary with atmospheric conditions ; rust or dust on wires ; influence of crop on nature of discharge ; current capacity of h.t. source of supply.

Electric discharge should be considered to be a stimulant as distinct from a nutrient, and it should be applied with discrimination. A useful bibliography is given in the original. R. E. N.

580. *Estimates of Load in Domestic Lighting.* **P. O. Reyneau.** (El. World, 71. pp. 969–971, May 11, 1918.)—This is a discussion of the methods by which the central station can estimate the probable increased demand which is likely to arise in districts in which the supply is mostly to houses

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and shops; in this way calculations can be made as to the feeders that will be required. Curves are constructed showing the max. monthly loads on a circuit averaged over three years, and also showing the max. loads in each month during the latest year over which the records extend. In this way the increases as percentages can be noted and tables drawn up showing how the loads in the different months compare with one another. From these, deductions can be made as to the further probable increases, and an estimate can be made as to the economy likely to result from any additional feeder.

W. H. S.

581. *Power Plant Practice during* 1917. **I. L. Kentish-Rankin.** (El. Rev., Chicago, 72. pp. 25–30, Jan. 5, 1918.)—Reviews generally the effects of the state of war upon the working of power-station boiler-rooms as regards fuel and labour and the means taken to overcome the difficulties which have arisen. Demands for economy have led to the installation of many mechanical devices in place of manual labour, and some typical instances are quoted with reference to the burning of low-grade fuel and the disposal of refuse from furnaces. W. N. Y. K.

582. *Change from Two-phase to Three-phase Four-wire System.* **H. C. Dean.** (El. World, 71. pp. 1084–1085, May 18, 1918.)—The New York and Queens Electric Light and Power Co., Long Island City, N.Y., had to meet a 80 % increase of load on the distributors. The capacity of feeders and regulators had been reached, and the methods open were: (1) to install more 2-phase feeders (2300 volts 4-wire), (2) to install h.t. feeders and relieve the larger 2300-volt feeders, or (3) to change to the 2300/4000-Y volts 3-phase system. Close estimates showed that (3) would require less than one-half the expenditure required by (1) or (2), and in addition future feeders would have 50 % greater capacity with only one-half the percentage line loss and voltage drop. The power load was four times the lighting load, and this involved much work in changing transformer banks, one transformer in each bank being replaced by two of half rating with 10 % taps. Diagrams show the connections. The method of making the change over is described.

W. N. Y. K.

583. *The Use of Synchronous Machines for improving the Power Factor.* **E. Poirson.** (Rev. Gén. d'Él. 3. pp. 859–862, June 15, 1918.)—The author considers that synchronous motors should be more largely used, and that they might even be run without load to improve the power factor: the consumer might be encouraged to install large motors of this type, so that they should be largely running on light loads. Something could also be done in the central station by running idle alternators as synchronous motors, or by running over-excited alternators in parallel: in case there are several generating stations, the reactive current could be divided between the stations. An example is given showing diagrammatically how this may be possible in favourable cases. The extended use of synchronous machines is recommended where they can be suitably used. W. H. S.

584. *The Operation of Interconnected Systems.* **J. P. Jollyman.** (El. World, 71. pp. 1020–1022, May 18, 1918.)—New problems may arise if the interconnecting lines are long as compared with any other lines operated by either system, or if the capacity of the interconnecting line is small relatively to the capacity of the systems, or if frequency changers are used. The author's notes are based on experience derived from the inter-

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connecting systems in the neighbourhood of San Francisco. When synchronising over lines of some length, no difficulty arises even if the voltages of the systems differ by as much as 10 %. But when each of the systems has a considerable generating capacity and load of its own, and the connecting line is long and has relatively small carrying capacity, there may be a decided tendency to pull out of synchronism. A swinging effect may arise which will overload the tie line and allow the systems to drop out of synchronism. The exchange line ought to have considerable carrying capacity beyond that required to carry the exchange of power. Similar results are noticed with frequency changers in consequence of the various lags, and this swinging is greater in degree than that due to a long small tie line. There is no way of overcoming the difficulty due to the characteristics of a frequency changer unless the load transferred can be kept from fluctuating rapidly. In the neighbourhood of San Francisco about 2000 miles of high-voltage circuits are interconnected, and in some cases the connecting points are 400 miles apart: no difficulties arise from interconnection, even over this extended area, beyond those alluded to. W. H. S.

585. *Power Factor and Energy Tariffs.* **A. Barbagelata.** (Elettrotecnica, 5. pp. 214–216, June 5, 1918.)—Two schools actually hold the field concerning the manner of allowing the consumer to pay for the magnetising current. One proposes to let the consumer pay at a certain rate for the reactive energy $\sqrt{}$VI sin ϕ, whilst the other proposes to let him pay a certain price for the apparent energy VI. The author considers the discussion rather academic, as it is impossible to determine exactly the charge which is to be borne by the central station in each particular case, since, for a given consumer's cos ϕ the charge aforesaid varies as a function of the total load of the main, of the distance of the consumer from the central station, of the hour of the day, etc. Practically both schools arrive at the same result, which consists in charging the consumer the same price both for VI cos ϕ and for a fraction of VI sin ϕ.

In order that a tariff should have the effect of stimulating consumers to improve their cos ϕ, it is evident that the meters must allow them to appreciate at a glance the economic advantage they can obtain in improving their cos ϕ.

The author and Guastalla have already demonstrated [Abs. 924 (1918)] that if in an ordinary double 3-phase wattmeter the connections of the pressure coils are changed so that the currents in these coils lag 60 deg., the wattmeter, instead of indicating the real power $P = \Sigma EI \cos \phi$, indicates the quantity $B = \frac{1}{2}P + \frac{1}{2}\sqrt{3} \times (\Sigma EI \sin \phi)$. The indications are independent of the equilibrium of the main, and practically independent of the ordinary voltage variations.

The author sets forth, therefore, to install both an ordinary double 3-phase meter and another one modified as explained. Adopting the charge p for the real power P and the charge f for the reactive power R, it is always possible to arrange that the energy indicated by the first meter be paid a, and that indicated by the second one be paid b, so that $aP + b[\frac{1}{2}P + \sqrt{3}(\frac{1}{2}R)] = pP + fR$. Diagrams of connections for the two meters are given, and two examples show the practicability of the system. E. B.

586. *Power Factor and Tariffs.* **Iliovici.** (Soc. Int. Élect., Bull. 8. pp. 179–288; Disc., 283–284, May, 1918.)—The author considers that some

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method of charging on the Arno system is necessary: the point in various countries is to avoid illegal methods. The consumer should pay for power actually consumed and also for a fraction of the wattless current. This fraction should be between $\frac{1}{4}$ and $\frac{1}{3}$. A power factor between 0·8 and 0·9 should be aimed at, and prices adjusted accordingly. The paper is mainly concerned with theoretical and practical considerations of the alterations which would be necessary in the existing types of meter for registering the wattless current. W. H. S.

587. *Electric Extra Pressures and Systems of Protection.* **L. Lombardi.** (Elettrotecnica, 5. pp. 186–190, May 15, and pp. 202–204, May 25, 1918.)—This article is the text of an experimental lecture the origin of which is to be found in the experiments made upon the artificial line already described [Abs. 60 (1918)]. The author's experiments were made in order to study the extra pressures caused by sudden variations of the conditions of a line and the efficacy of the different types of dischargers.

After reviewing the previous experiments of Morecroft, Wagner, and Petersen, the author explains the formation of travelling and stationary waves, the laws governing them, and their physical representation. The conditions giving rise to especially high values of the potential are mathematically explained and practically shown by experiments.

Three cases are especially considered: (1) The sudden short-circuiting of a line. (2) The sudden switching on of a line. (3) The sudden insertion in a line of a low-impedance shunt. In the three cases the highest potentials, and therefore the greatest danger, occur when the resonance conditions are fulfilled. Special attention must be given to the rapidity of the break or of the switching on, in order to avoid the phenomenon of the inversion of the charge which was first observed by Sarfert [E.T.Z., 1914, page 402]; quick-break switches, especially if in oil, allow, at least partially, of avoiding the occurrence of this phenomenon.

The travelling waves generated in the cases just referred to constitute by far the greatest danger for electric lines; in comparison, the danger represented by atmospheric influences is much less, except in the case where they give rise to short-circuits or to destruction of insulators, as in these cases the much larger power of the machines is put in action. The question, therefore, of knowing whether atmospheric discharges are oscillatory or not is almost superfluous, as in both cases the danger is the same. The ideas which were accepted up till now in the construction of line dischargers are, in the light of the conclusion aforesaid, largely inexact, the violent discharge to earth being able to give rise to extra pressures greater than those of the atmospheric charge which had to be eliminated by the discharger. In an analogous manner the inductances often employed in dischargers can contribute towards increasing the potential, and so produce just the contrary effect to that for which they were employed. This danger can be diminished by deriving suitable resistances between the ends of the inductances, as proposed by Campos [Abs. 58 (1912)].

Three series of experiments were made upon artificial lines differently constituted, suitable insertions of resistances, inductances, and capacities allowing the constitution of the principal types of line dischargers to be reproduced. The results of these experiments show that probably the Campos devices composed of inductances and resistances in parallel and of condensers and resistances in series are the most perfect of such dischargers.

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In conclusion, the author agrees with Petersen in estimating that the best protection for installations consists in their rational construction in making equal, as much as possible, the characteristic constants of the different parts and in avoiding, especially at the ends of the different branches, the association of inductances and capacities. E. B.

588. *Installation of Current-limiting Choking Coils.* **M. E. Skinner.** (El. World, 71. pp. 924–927, May 4, 1918.)—A number of factors that are vital to the successful operation of current-limiting choking coils are not under the control of the designer but depend on the mode of their use. A number of considerations that must be taken into account in installing this type of apparatus are set out.

The most common type of choking coil is a cylindrical coil with bare turns supported at intervals by a fireproof non-magnetic structure. Although the voltage across the coil at full load is seldom more than 5 % of the phase voltage, nevertheless the voltage may rise on short-circuit to such a value that there is danger of breaking down the insulation between the turns. The coil should be mounted indoors, as the insulation depends greatly on the presence of moisture, steam, metallic vapours, or dust in the air.

Inflammable materials should not be used in the design, as very great evolution of heat accompanies a short-circuit. It is shown that the lower the percentage reactance for a given current-carrying capacity the greater should be the cross-section of the copper in the coil if undue temperature-rise is not to take place. The coil should be designed so that a short-circuit current lasting about 2 secs. will not overheat it. The design of choking coils situated between sections of the bus-bars should be more ample.

Heat is also often developed outside the coil by the action of the wide-spread magnetic field upon the structural steel-work of floors, ceilings, etc., in the neighbourhood. To meet this difficulty the coils should be mounted so that they are not coaxial with the meshes of steel work, and such steel work may be provided with insulating joints to avoid the flow of circulating currents. The distance between the coil and the steel work should be as great as possible. Trouble is commonly encountered by the overheating of the reinforcing metal work of concrete floors and walls.

A series of tests were made with a coil of 51 in. diam. and 78 in. length, containing 54 turns carrying 1600 amps. at 25 cycles. The temperature-rise in metal objects in the neighbourhood was measured and a table is given. A rise of 25 deg. C. was measured in a $\frac{1}{8}$-in. boiler-plate placed 25 in. from the top of the coil, and 84 deg. C. in a $\frac{1}{4}$-in. boiler plate at the same distance. Other results of this nature with metal pipes, beams, etc., are given in the table.

Forces are set up between the adjacent turns, between the coil and magnetic materials and between adjacent coils. The latter stress must be carefully borne in mind when installing the coils, which should, on 3-phase systems, be separated by a distance equal to one-third of their diameter when side by side, and half of their diameter when coaxial, and if this is done external bracing between the coils will generally be unnecessary. The most dangerous cases are those in which adjacent coils may simultaneously carry short-circuit currents in phase with each other—for instance, when two adjacent feeders of the same phase enter the same substation. A. J. M.

589. *Wooden Poles for Electric Railways.* **C. R. Harte.** (El. Rly. J. 51. pp. 743–747, April 20, 1918.)—Wooden poles offer the advantages of low first

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cost, easy supply, and easy erection. On the other hand, they are subject to decay and to injury by insects, fire, lightning, woodpeckers, sleet, and wind. The average life is about 12 years. Cedar furnishes about two-thirds of the poles in use (in America); this timber is relatively long-lived, and is strong, light, straight, and well-distributed over the country. Two-thirds of the cedar poles are of the northern white variety. Winter-cut poles are best. Chestnut averages 12 years' life compared with 18½ for all the cedars except juniper; supplies have, however, been checked by the prevalence of "blight" or bark disease. At present there is little chestnut left east of the Appalachians and north of Virginia. Pine needs impregnating if it is to give long life. Western yellow pine is being used to an increasing extent and, unlike some pines, it takes preservative readily; the tree grows commercially in more than a third of the U.S. Lodgepole pine killed by fire is often good for use (after impregnation) for some years afterwards. Timber species less valuable for lumber are being used increasingly for poles (impregnated). Cypress lasts 100 to 250 years as shingles, but is of uncertain durability in pole service. Redwood poles are strong and durable, but, being sawed from logs, they are of variable size and taper. Other timbers are used locally, and the ratios of the maximum use of the most important to the total are as follows:—Balsam, bois d'arc (0·5 %), butternut, catalpa, cherry, chinquipin, cottonwood, Douglas fir (0·7 %), elm, hemlock, locust (0·8 %), mulberry, osage orange (0·6 %), sassafras, spruce (0·8 %), tamarack (0·8 %), walnut, willow.

The fact that poles often last longer in the district where they were grown than elsewhere, is probably due to their being "inoculated" with local fungi and bacteria whilst alive. Rot is the principal cause of pole failures, and most rots require air, moisture, and heat. The author discusses the cause, symptoms, and relative seriousness of various defects and disease to which timber is subject in growth and in service. Tables are given showing minimum pole dimensions for natural poles; also the compensation to be made for hollow heart by increased girth. R. E. N.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

590. *Walnut Station of Columbus Railway, Power and Light Co.* (El. Rev., Chicago, 72. pp. 825–831, Feb. 28, 1918. El. Rly. J. 51. pp. 407–411, March 2, 1918. El. World, 71. pp. 450–458, March 2, 1918.)—A detailed description of the new station of this company, 10 miles from Columbus, Ohio, with plan view and photographs of coal-storage bins, vertical centrifugal motor pumps, and 18,200-volt bus-bar structure, also 18,750-kv.a. unit. The present plant comprises eight 440-h.p. boilers, each of 4440 sq. ft. heating surface, 250 lbs. steam pressure and single-loop superheaters giving 440 deg. F. superheat; the boilers are two in a battery, with one 6800 sq. ft. economiser per battery. The flue gases are delivered into a concrete flue at the base of a 150-ft. concrete chimney. There is no economiser by-pass. The condensate from the condensers is pumped in a 6000-gall. tank on top of the boiler-room, with a 8000-gall. make-up water tank; this water passes through a 1800 sq. ft. heating surface feed heater. The boiler feed pumps comprise three 400-gall. per min. centrifugals driven at 1740 r.p.m. by a 100-h.p. induction motor each, and one by Curtis steam turbine at 1850 r.p.m. There are four 200-gall. per min. centrifugals supplying water for the water purifier for cooling the generator bearings and for cooling the 15,000-kv.a. transformers. The main turbo-generator is a Curtis horizontal unit, 1800 r.p.m. 235 lbs. pressure, 150 deg. F. superheat, with 18,200-volt, 3-phase 60-cycle alternator. Full-

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load consumption is 11·85 lbs. water per kw.-hour. The main condenser has 28,900 sq. ft. cooling surface. The circulating pumps of 12,500 galls. per min. capacity are each driven by 120-h.p. motor. The generator voltage is stepped up to 39,400 volts for transmission. The transformers and bus-bar structure are outside the building. W. E. W.

591. *Interconnected Power Systems of the Southern States.* (Power, 47. pp. 720–727, May 21, 1918.)—In four of the Southern States there is a high-tension transmission line about 1000 miles long, linking up the systems of five large companies. The only large company not connected is the Alabama Power Co. The U.S. Geological Survey estimates the available power in the headwaters of the Appalachian mountains to be 2,800,000 h.p., and for all the systems of the South 5,000,000 h.p. Three companies have an output of over 100,000,000 kw.-hours per annum, namely :

	Peak Load.	Output.	Load Factor.
	Kw.	Kw.-hrs.	%
Tennessee Power Co.	85,200	547,945,475	78·41
Alabama Power Co.	58,250	289,715,125	56·7
Georgia Railway and Power Co.	78,200	258,607,882	—

The Alabama Power Co. owns sites where 500,000 h.p. can be obtained on the Coosa and other rivers ; at present 45,300 kv.a. is installed in four substations supplied at 110,000 volts. The steam auxiliary capacity is 25,000 kw., supplying 7·55 % of the total output. The Carolina Power and Light Co., in addition to its own property, controls the Yadkin River Power Co. and the Asheville Power and Light Co. The Asheville Co., among other systems, operates 188 miles of high-tension transmission line connecting two hydroelectric (3300 and 530 h.p.), and three steam (5000, 950, and 300 h.p.) plants. The Yadkin River Power Co. has a 32,000-h.p. installation at Blewett Falls, near Rockingham, N.C., with 184 miles of high-tension transmission line. The power station is one of the most modern. The Columbus Power Co. has three hydroelectric stations on the Chattahoochee River, totalling 22,750 kv.a. Current is generated at 11,000 and 5500 volts, stepped up to 66,000 volts for transmission, 3-phase 60-∿. Standby supply of 3000 kw. can be obtained from steam turbo-generators. The Georgia Railway and Power Co. has a 100,000-h.p. hydroelectric plant at Tallulah Falls, and extensions in progress will double the capacity. There is 300,000 h.p. capacity in undeveloped property. The Southern Power Co. generates at 2200, 6600, and 11,000 volts 3-phase 60-∿. The transmission system originally designed for 11,000 volts has been adapted to 44,000, and recent lines are for 100,000 volts. All lines are looped in together. The stations are : Great Falls, 24,000 kw., 72 ft. head : Rocky Creek, 24,000 kw., 63 ft. head ; Ninety-nine Islands, 18,000 kw., 72 ft. head ; Catawba, 6600 kw., 25 ft. head ; Lookout Shoals (under construction) 24,000 kw., 76 ft. head ; and three steam stations of 8000 kw. each. The Tennessee River Co. has four hydroelectric stations of 85,000 kw. combined capacity, and rights have been obtained for 85,000 kw. more at three stations on the Ocoee River. Supply is supplemented by steam plants at Chattanooga (5000 kw.), Nashville (15,000 kw.), and Knoxville (4000 kw.). [See Abs. No. 209 (1917).] W. N. Y. K.

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592. *Electrical Distribution of Power in the Neighbourhood of St. Nazaire.* **J. de Soucy.** (Rev. Gén. d'Él. 3. pp. 857–872, March 9, 1918.)—A map is given, showing the district served. The power station at St. Nazaire, on the Loire, contains 5 turbo-generators, varying from 1000 to 5000 kw., which have been installed at different dates, the latest having been supplied by the Oerlikon firm and put to work at the end of last year. The undertaking has developed considerably during the war: particulars are given of all the five units. The output is in 3-phase current at 5000 volts and 50 ∿. Belleville boilers and superheaters are used. The paper contains a number of drawings, diagrams, and photographs. The most important consumer is the naval dockyard of Penhoet, which is situated in a part of Saint Nazaire: there are also other shipyards in the same district; current is supplied partly as alternate current and partly as direct current at 460 volts. Some particulars are also given as to the outlying districts in which current is supplied at high tension. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

593. *The Nuremberg-Fürth Electric Railway.* **P. Scholtes.** (Elekt. Zeits. 39. pp. 161–163, April 25, 1918.)—A previous article by the author dealt with the design and equipment of this line [Abs. 1140 (1905)]. The present article deals with the results which have followed from the adoption of the third-rail system at a later stage owing to electrolytic troubles and disturbance of telephone circuits. Figures, diagrams, and records are given, which show that at the present moment these difficulties have disappeared. The author considers that it is desirable to return the current to the station mainly by insulated conductors, and that the rails should only be regarded as equalising circuits; in this way the heaping-up of the current in uninsulated rails is avoided. W. H. S.

594. *Electric Traction on Canals.* **A. Tumerelle.** (Rev. Gén. d'Él. 3. pp. 865–874, June 15, 1918.)—The author considers that this question will be considered to be important after the war, and alludes to the methods of hauling by tractors and by the funicular system, giving instances of each. Tractors are at present employed on a canal connected with the Oise, and the funicular method is used on a length of 5 km. on a canal connecting the Marne and the Rhine. A number of details of these installations are given; the author considers that the funicular system has many advantages, speeds from 1·5 to 5 km./hr. being possible. The stretch of 5 km. on the Marne–Rhine canal is between Fong and Pagny-sur-Meuse, and was selected on account of the difficulties that were encountered with other modes of traction. W. H. S.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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TELEGRAPHY AND TELEPHONY.

595. *Theory of Free and Sustained Oscillations.* **H. G. Cordes.** (Inst. Radio Eng., Proc. 6. pp. 167–176, June, 1918.)—The first part of this paper consists of a mathematical study of the free oscillations produced in a circuit having capacity, inductance, resistance, and leakage. The transient and permanent conditions with sustained oscillations are then treated in a similar manner. The resonance and energy relations of such circuits are carefully considered, together with the influence of leakage and resistance on the period and decrement of the oscillations. A. W.

596. *Electron-discharge Apparatus.* (Wireless Age, 5. pp. 279–281, Jan., 1918.)—Describes a new vacuum tube perfected by I. Langmuir. The filament of this new tube consists in part of thorium, which at a given temperature has a much greater electron emission per unit surface than tungsten. In the preparation of the tubes great care must be exercised to remove the last traces of oxygenous gases, particularly water-vapour, and care must be taken not to evolve water-vapour from the bulb walls during operation. The kathode consists of thoriated tungsten and is prepared by adding a thoria compound, such as nitrate of thorium, to the tungsten oxide before reduction, or by adding thorium nitrate or thoria to the metal powder after reduction. A small amount of potassium is introduced into the bulb before sealing off from the vacuum system, the presence of this material preventing the oxidation of the thorium. After sealing off the bulb the thoriated filament is heated to about 2900° K. for about a minute. The treatment of the filament at this temperature appears to be desirable for purifying the surface of the kathode. The kathode is then heated to about 2000° to 2400° K., and by this temperature treatment some change is produced in the kathode which enormously increases its electron-emitting property. The greatest activity is obtained between about 2200° to 2300° K., and the treatment at this temperature is usually continued for about a minute. Apparently a concentration of metallic thorium or some other oxidisible thorium material takes place on the surface of the filament. The anode is cylindrical or cup-shaped, and is made of some highly refractory metal, such as tungsten. With filaments prepared as above Langmuir has obtained at a temperature of about 1300° to 1380° K. substantially the same electron emission per cm.^{2} as with a pure tungsten filament at about 2000° K., *i.e.* about 8 milliamps per cm.^{2}. A thoriated kathode may be operated at a temperature of 1700° to 1800° K., at which temperatures its life is long, and thermionic currents may be obtained many thousands of times greater than are obtainable with pure tungsten at the same temperature. The tubes form very efficient rectifiers. A. W.

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Sept. 30, 1918.] *Entered as second class matter at the New York, N.Y., Post Office, February 28, 1909* [No. 249

SCIENCE ABSTRACTS

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

SEPTEMBER 1918.

PRIME MOVERS.

STEAM PLANT.

597. *Possibilities with Higher Steam Pressures.* **E. Berg.** (El. World, 72. pp. 49–50, and 56–58, July 13, 1918.)—Considers the theoretical gain to be obtained by the use of steam at pressures higher than 200 lbs. per sq. in., and by superheat. The actual gain by superheat is about 2½ times the theoretical gain, owing to the reduction of loss due to friction in nozzles and blades and in windage. The proportionate losses with dry steam are :—

(1) Loss due to friction in nozzles and blades and windage of discs and blades	20 %
(2) Leakage loss	8
(3) Rejected energy (residual steam velocity)	8
(4) Bearings, packing, etc.	1
Total	27 %
Efficiency of turbine	78 %

Superheat of 200 deg. F. reduces loss (1) to about 15 %.

Tables show theoretical water-rates per hour and gain in fuel by increasing pressure up to 1000 lbs. per sq. in. [See Abs. 223 (1917) and 802 (1918).]

W. N. Y. K.

598. *Causes of Impaired Turbine Economy.* **J. Y. Dahlstrand.** (El. World, 72. pp. 4–7, July 6, 1918.)—Decrease in steam economy is considered; the most common cause is the falling of vacuum, especially in small turbines. Another cause is, working at a lower load than the turbine is rated for. Curves show the effects of varying load and reduced vacuum on steam consumption of turbines designed for 150 lbs. pressure and 27, 28, and 29 in. vacuum. It is not unusual to find a turbine designed for 28 in. vacuum

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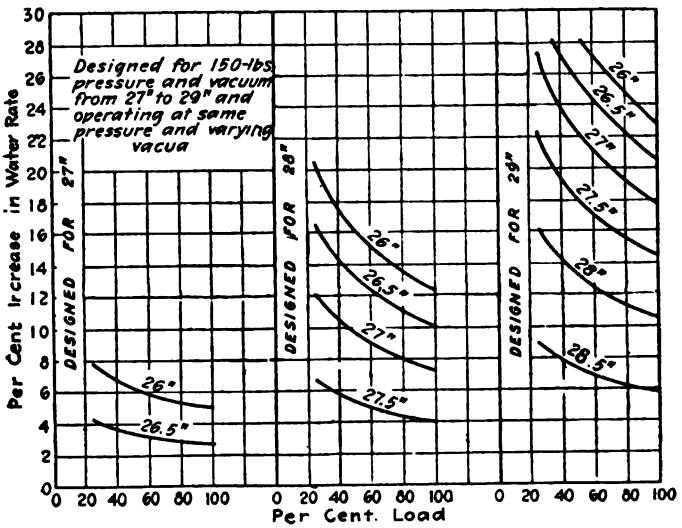
operating at 25 in. with a loss of 16 % steam. Falling off in vacuum may be due to air leaks, or to dirt in condensing plant, and in certain cases with low-pressure turbines to steam leaks. Internal leakage is also a cause of loss of economy, and this may be due to the wearing out of packing rings or bushings, excessive clearance in the labyrinth packing or between stationary and rotary elements. A considerable amount of trouble has been experienced with erosion, particularly with single-wheel impulse turbines where the relative velocity of



—EFFECT OF LOAD AND OTHER THAN RATED VACUUM ON WATER RATE

the steam is high; this is more common with wet than with dry steam. Another cause of impaired efficiency is the blocking of the turbine passages by deposits of foreign substances, *e.g.* mud and scale from boilers working at a high rate. To obviate this trouble a lubricator is sometimes fitted in the steam line: the lubrication prevents the solid matter from adhering to the blades. The most effective method is to fit a receiver near the turbine throttle; this may be combined with a steam separator. W. N. Y. K.

599. *Coal-saving by Scientific Control of Steam Boilers.* **D. Brownlie.** (Engineering, 106. pp. 25–27, July 12; 55–57, July 19, and pp. 267–268, Sept. 6, 1918.)—Gives average figures obtained from fuel consumption tests of 250 typical boiler plants from 1910 to date and discusses them with a view to supplying accurate data as to the economy obtainable in coal consumption.

The interim report on electric power supply in Great Britain of the Reconstruction Committee allocates the total annual output of coal of all the mines of the United Kingdom, taking 1913 as typical, *i.e.* 287,000,000 tons, of which 189,000,000 were consumed at home, as follows :—

1. Railways	15,000,000 tons	6. Other metals, etc.	1,250,000 tons
2. Coast steamers	2,500,000 „	7. Chemical works, etc.	5,750,000 „
3. Factories	60,000,000 „	8. Gas works	18,000,000 „
4. Mines	20,500,000 „	9. Domestic	85,000,000 „
5. Iron and steel	31,000,000 „		

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The method of carrying out the tests is described, and a list of the industries represented is given. The test results are tabulated and analysed to show the average results for 100 plants with Lancashire boilers and 250 plants with all classes of boilers. Details are segregated for groups of 75 collieries, 20 cotton mills, 10 lace mills, 16 general chemical factories, 22 explosive factories, 26 dyers and bleachers, 21 woollen mills, 9 hosiery mills, and 21 paper mills. The results are summarised, and it is estimated that if all the plants were brought to an efficiency of 75 % the annual saving of coal would amount to 480,000 tons. **Morgan** (*ibid.* pp. 152–153, Aug. 9), **W. H. Casmey, G. A. Rossetti, J. Bowman** (*ibid.* pp. 287–288, Aug. 30, 1918).

W. N. Y. K.

600. *Blower for Water-tube Boilers at Bristol.* (Engineering, 106. p. 126, Aug. 2, 1918.)—Four boilers, complete with stokers, superheaters, economisers, and forced and induced draught plant, have been installed as an extension of the Corporation Electricity Works. Each boiler has 5400 sq. ft. heating surface, working pressure 200 lbs. per sq. in., and superheat 200 deg. F.; the chain grates for each boiler have 116 sq. ft. area. The economiser for each pair of boilers has 288 tubes 11 ft. long. Each pair of boilers is served by a 55-in. induced draught fan, two fans exhausting into one chimney 8 ft. 6 in. diam. and 65 ft. high. A 60-b.h.p. motor drives each fan. The whole boiler plant is carried on concrete arches sprung between girders so as to permit of ready access to the under parts and to facilitate removal of ash. The boilers have straight tubes expanded into flats pressed in the plating of the upper and lower drums. As much as 9½ lbs. of water per sq. ft. heating surface has been evaporated with the stokers working at full capacity. The max. efficiency has been maintained when evaporating 6 lbs. water per sq. ft. heating surface. The plant was installed by John Thompson, Wolverhampton.

W. N. Y. K.

601. *Improving Boiler-room Operation.* **I. L. Kentish-Rankin.** (El. Rev., Chicago, 72. pp. 986–989, June 15, 1918.)—Discusses the possibilities of increasing the capacity of boilers with existing apparatus and thus saving coal. Heat losses are reviewed under two heads: unavoidable, and partly avoidable. Various steps which may be taken to reduce heat losses are set out, and the uses of the steam-flow meter, draught gauge, and CO_2 recorder are indicated. The importance of proper records is insisted on and a specimen report sheet is drawn up. Soot cleaning is specially dealt with. The loss of conductivity of boiler plate due to soot is quoted thus:—

Thickness of soot.	Percentage Loss of Conductivity.
Nil	0·0
$\frac{1}{32}$ inch	9·5
$\frac{1}{16}$ „	26·2
$\frac{1}{8}$ „	45·2
$\frac{3}{16}$ „	69·0

W. N. Y. K.

602. *Theoretical and Experimental Study of Turbine Blades.* **M. Poincet.** (Comptes Rendus, 166. pp. 989–991, June 17, 1918.)—This paper contains the results of a theoretical and experimental study of the loss which occurs at turbine blades and of the various factors which influence the magnitude of the loss. Friction at the walls, speed of the steam, overheating, and play

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between the blades, have only a very slight effect. The elements contributing most towards the loss are: the width of the injection sector, the depth of the blades, the shape of the channel, and the impinging angle. H. H. Ho.

603. *Properties of Steam.* **A. J. Nicholson.** (Engineer, 126. p. 8, July 5, (1891.—Remarks in a letter on the article concerning the determination of the latent heat of steam by F. B. Aspinall [see Abs. 539 (1917), 962 (1918), and *ibid.* 125. pp. 525–527, June 21, 1918.] If steam as defined by Aspinall is generated in boilers, then boiler efficiencies higher than supposed are being realised, while turbine efficiencies are lower. Tests on a water-tube boiler with special reference to superheating made by H. Yarrow (Inst. Naval Architects, Trans. 1912) are taken and Aspinall's value of the heat units in the steam are compared with the values given by the steam tables, the former crediting the steam with nearly 12 % more heat than the latter. It would be helpful if it were stated what values are to be taken for (*a*) sensible heat and (*b*) specific heat of superheated steam. The relationship between steam pressure and temperature is questioned. **F. B. Aspinall.** (Engineer, 126. p. 60, July 19, 1918.)—Aspinall discusses the letter of J. T. Nicholson pointing out the false notion which arises when the accepted steam tables are applied to the heat analysis referred to. The steam entering the superheater was supposed to be at the point where superheating commenced, whereas it carried 14·6 % water; *i.e.* the superheater had to supply to every lb. of steam 970–828·3, or 141·7 B.Th.U. before superheating commenced. The sensible heat supplied was the difference between feed temperature and temperature of the steam before superheating. The accepted values for the specific heat of superheated steam are believed to be inaccurate. No error has been found in the pressure and temperatures in the accepted steam tables if the thermometer was properly placed and shielded and the observed readings were checked by standard instruments.

W. N. Y. K.

604. *The Storage of Bituminous Coal.* **J. H. Anderson.** (El. Rev. 83. pp. 78–79, July 26, 1918. Abstract of paper read before the Inst. of Marine Engin., June, 1918.)—These notes are based upon the experience gained with a very large tonnage of stored coal; the special observations, however, being based on the methods adopted with a pile of 16,000 tons stored in the open and containing many varieties of bituminous coal, all high in volatile matter. The plan of the heap was a triangular-shaped figure with a surface area of about 46,000 sq. ft., an average depth of 18 ft. and a max. depth of 16 ft. The actual pile consisted of North Country, Scotch, and Yorkshire coals. Temperature readings were taken at 14 different places nearly every day, at the same depth from the surface, and occasionally readings were taken at the vent-pipes, of which there were 50 in this heap. From previous experience the warmest place was found to be between 6 and 8 ft. deep from the surface, so from this, a depth of 7 ft. was established, as the standard depth to record temperature. The temperature tubes were ¾-in. or 1-in. gas tubing, and driven from the top to the bottom of the coal. They should be long enough to project 2 or 3 ft. above the coals; and each tube had a numbered metallic label, so that it could easily be recognised.

Regarding vent-pipes, in most cases these were old scrap tubes about 8 ft. long and 3 to 4 in. in diam., and provided with a burr, which prevented the coal going down inside the tubes. To facilitate the driving into the

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coal the ends of the tubes were flattened to chisel shape, just leaving an aperture of about ½ in. The vent-pipes were driven down to the 7-ft.mark, leaving about a foot projecting above the coal. By taking periodical readings of the heat of the pile, and comparing them with previous readings ample warning of fire is obtained, and 90° F. was made a "warning" temperature. When this reading was obtained at any place, four further temperature pipes were driven down, north, south, east, and west, about 10 ft. from the warm pipe. The next day the readings of these four pipes were carefully noted. The highest one would then be made the centre, and further pipes would be put down in this direction, the idea being to locate the source of heating. When this warmest place was found, an additional vent-pipe would be put in there, which generally arrested the rise of heat. 100° F. was made a danger reading; that is, if the insertion of a vent-pipe failed to arrest the rise of temperature but allowed it to reach 100° F., orders were given for a trench to be dug, 1 ft. deep, on every occasion. Thus if the daily readings were at 100° F., say for three days, then this spot would be trenched 8 ft. deep. At no time, however, did the readings of this pile reach 100° F. Probably the trenching on this occasion would have been unnecessary if additional vent-pipes had been inserted, for this was the hottest part of the pile throughout the whole period, and it was in the neighbourhood where the coal was deposited to a depth of 16 ft. J. B. C. K.

GAS, OIL, AND WATER ENGINES.

605. *New Clarkson Coke-fuel Steam Motor.* (Engineer, 126. pp. 101–108, Aug. 2, 1918.)—Experimental work which has led to the production of this motor began in 1913 when a 3-ton lorry (gross weight 6 tons 11½ cwt.) averaged 4 lbs. coke per mile at 12 miles/hr. on a London to Brighton trip.

The more extensive use of gas coke is very desirable at present. The vehicle here described has been designed for operation by comparatively unskilled drivers and the arrangement of pedals and control levers is identical with the arrangement usual on petrol vehicles. In order to reduce the size of engine required a gear box is provided for use with very heavy loads and soft ground. Once the principle of the gear box is admitted, construction may be simplified by eliminating the ordinary reverse gear and having a free engine. The new engine has been run quietly for hours, regulating its water feed, lubrication and steam pressure without any attention.

The power unit, comprising engine, boiler and condenser, is designed primarily for road transport work but should be suitable also for marine and other service where a light power unit is needed. The boiler has two cylindrical steel shells flanged and bolted together at each end; no welds or rivets are used in the boiler. The inner shell is provided with a number of "thimble" tubes (about 4 in. long × 1¼ in. average diam.) which are pressed into the plate and held tightly by the working pressure in the boiler (300–350 lbs. per sq. in.). An oscillating valve regulates the fire draught so as to maintain this pressure automatically. Coke is fed to the grate through a central tube from the top of the boiler. A superheating coil round this central tube permits steam to be superheated to 620° F. The water feed is controlled automatically by a float which prevents the foot valve of the feed pump from closing except when it is necessary to pass water into the boiler

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to maintain the working level. The feed water impinges on a thin steel plate between the inner and outer boiler shells; any deposits are formed on this baffle plate and fall thence to the bottom of the boiler. Rocking fire-bars are employed. On a 3-ton lorry it is necessary to replenish the fire every 12 or 15 miles, and the water every 30 to 60 miles.

The engine is a V-type, tandem compound machine with two pairs of high- and low-pressure cylinders operating the same crank at an angle of 90°. The cylinder diams. are 3 in. and 5 in., the stroke is 3 in. For cylinder lubrication, a trigger pump delivers one drop of oil into the steam pipe per 100 revs. of the engine. All other parts are lubricated under pressure by a flooded gear-pump. The condenser is fan-cooled and the bottom header is suspended (in guides) by the tubes. There is therefore no risk of injury by expansion or vibration. A fan is provided for cooling purposes. It is claimed that with speeds up to between 20 and 30 miles/hr. a 3-ton lorry consumes 5 lbs. of coke per mile; when running light the consumption is often down to 3½ lbs. per mile. With coke at 35s. per ton and petrol 2s. 3d. per gall., the respective fuel cost is 1:4 in favour of coke. The original article is illustrated fully. R. E. N.

606. *Air Propeller Performance and Design by Specific Speed Method.* **M. C. Stuart.** (Am. Soc. Naval Eng., J. 30. pp. 315–333, May, 1918. Am. Soc. Mech. Eng., J. 40. pp. 715–716, Aug., 1918. Abstract.)—The method of treatment developed for the performance and design of geometrically similar air propellers is an adaptation and extension of methods which have been applied successfully to water turbines, centrifugal fans, and centrifugal pumps. The specific speed of a propeller operating at given efficiency is defined as the speed of a geometrically similar propeller of such diam. as to produce unit power at unit velocity, with the same efficiency. Conversely, the specific diam. is defined as the diam. of a geometrically similar propeller which produces unit power at unit velocity, with the same efficiency. The specific tip speed of a propeller may be defined as that of a geometrically similar propeller producing unit forward velocity at the same efficiency. Defining the specific speed, specific diam., and specific tip speed of any propeller operating at any efficiency as the speed, diam., and tip speed of a geometrically similar propeller which develops 100 h.p. thrust when the forward velocity is 100 miles/hr., formulæ are developed for these three specific units. From test data of any propeller of the type, the specific units and efficiencies are plotted as curves which cover completely the design and performance of all propellers geometrically similar to the one tested. It is not necessary to use slip and slip function in the specific speed method. Whereas coefficients and functions now used in propeller problems are abstract numbers without tangible significance, the specific units used by the author may be thought of as speeds and diams. for unit performance, and the actual speeds and diams. are proportional to the specific units. By the new method all performance or design problems for a group of geometrically similar propellers may be solved by a single curve and the simple formulæ for the specific units. Also, the characteristics of various types of propellers may be compared upon coordinates showing directly the value of propellers as regards required performance. R. E. N.

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PROPERTIES OF ENGINEERING MATERIALS.

607. *Testing Hardness of Metals by the Boyelle-Morin Apparatus.* **C. J. B. Cooke.** (Inst. Mech. Eng., J. 5. pp. 331–333, June, 1918.)—This apparatus is portable and can be used upon castings and forgings; it consists of a tube carrying a hardened steel ball and a rod arranged to slide freely in the tube. Interposed between the lower end of the rod and the ball is a specimen of steel from a bar of known hardness. The apparatus is held vertically with the ball resting on the surface to be tested, and the top of the bar is struck sharply with a hammer, causing the ball to indent the specimen of known hardness and also the steel, of which the hardness is required. The diameters of the two indentations are measured by a scale and magnifying glass, and the corresponding hardness numbers are read off on a specially graduated slide-rule.

Comparative tests with the apparatus and a 3000-kg. Brinell machine on 18 specimens of steel ranging from 0·15 to 0·64 % carbon and from 121 to 255 Brinell hardness gave results differing on the average by 2·4 from the Brinell numbers. C. O. B.

608. *Annealing and Recrystallisation of Cold-rolled Aluminium Sheet.* **R. J. Anderson.** (Met. and Chem. Eng., 18. pp. 523–527, May 15, 1918.)—The common practice employed for annealing cold-rolled sheet Al is to heat the metal for 18 to 30 hours at a temperature of about 375° C. and subsequently allow it to cool in air. The max. softness attainable for material of commercial purity is 4–5 on the Shore scleroscope scale. When hard-rolled the material has a Shore hardness of 13–15. The hardness of the annealed sheet is no measure of its ductility; the coarse-grained material obtained by an annealing of 30 hours at 400° is very weak, although its hardness is only 4. When annealed at 400° even for short periods, the metal "blistered," an effect also produced by prolonged heating even at 350° C. The formation of these blisters is dependent on the temperature and speed of pouring the original cast metal. Prolonged annealings are very harmful, rendering the metal coarse and weak. Micrographs of the material, as rolled and after annealing, are shown. The structure of the cold-rolled sheet appears to be chiefly amorphous, no evidence of crystallinity being discernible. Recrystallisation on annealing occurs very slowly, complete softening resulting when only slight traces of recrystallisation are visible. Recrystallisation of the hard metal when annealed under constant conditions of temperature and time occurs more readily as the degree of cold work put upon the sample is increased. The results of the tests show that there is no necessity for the common practice of annealing Al for 24 hours at 375° C., a much shorter period being sufficient. [See Abs. 537 (1918).] F. C. T.

609. *The Lubrication of Michell Blocks.* (Brown-Boveri Review, 1918. Engineering, 105. pp. 714–715, June 28, 1918. Abstract.)—In the applications hitherto made of Osborne Reynolds' theory of lubrication, it has been assumed that the viscosity of the lubricant does not vary as it passes through the bearing. For efficient lubrication, therefore, a Michell block must be

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supported behind its centre of figure in order to secure the necessary fine wedge of oil between the opposing surfaces, and, moreover, such a block, if centrally supported, should have no load-carrying properties whatever. By actual experiment, however, Kingsbury and Parsons have found that a centrally-pivoted block could carry quite a high load. Newbigin has pointed out that this experimental result was due to the fact that in applying Reynolds' theory the variation of the viscosity of the oil as it rose in temperature during its passage through the bearing had been neglected, and that when this factor was taken into account the experimental facts were quite in accord with theory. The effect of this changing viscosity of the oil has now been further investigated, both theoretically and experimentally, by the firm of Brown, Boveri and Co., of Baden, Switzerland, and an account of these researches appeared in 1917 in their publication known as the Revue B.B.C.

For a block infinitely wide as compared with its length measured in the direction of motion, Reynolds gave the equation $dp/dx = -6\lambda(h-h_1)k^3$, where p denotes the pressure of the oil, x the distance of any point of the block from the origin, and λ the viscosity of the lubricant, whilst h denotes the distance separating the opposing surfaces at any point x, and h_1 is the value of h at the point where the pressure is a maximum. In integrating this equation, Reynolds assumed λ to be constant, although the temperature of the oil may be greatly increased by its passage under the block. In the Revue B.B.C. the assumption is made that the viscosity λ may be expressed in the form $\lambda = \lambda_0(1 + xn/a)$, where λ_0 denotes the viscosity of the oil as it leaves the block, whilst "a" denotes the length of the block and n a coefficient. The viscosity of the oil as it enters the block is therefore $(1 + n)\lambda_0$. With this substitution the above equation can still be easily integrated, and the results for particular values of the constants are discussed in the paper accompanied by illustrative curves. It is shown that to carry a given load the oil film will be thinner with a centrally-pivoted block than with one which is pivoted behind the centre line. The thinner film will be subject to a more severe shearing action, and the development of heat should be greater than with the centre of pressure behind the centre of figure. This conclusion is borne out by Newbigin, whose results are given in the paper. The total load carried per unit width of an infinitely wide block when the viscosity varies as above is found to be: $P/b = 6\lambda_1 V_a^2 \psi_1/h_0^2$; here total load is P/b, $\lambda = \lambda_0(1+n)$ denotes the viscosity of the oil at the leading edge, λ_0 the viscosity at the trailing edge, V the velocity of motion, h_0 the least thickness of the film, "a" the length of the block measured in the direction of motion, and Ψ_1 a function which depends on n and m where m is the inclination of the block of the other bearing surface. Experiments testing this conclusion are quoted. In conclusion Michell's calculations show that when a block is of finite dimensions the displacement of the centre of pressure from the centre of figure becomes greater the narrower the block is as compared with its length in the direction of motion. The effect of side leakage is therefore to increase the eccentricity of the resultant pressure on the block, whilst, on the other hand, the rise in the temperature of the oil tends to decrease this eccentricity. H. H. Ho.

610. *The Viscosity of Lubricating Oils.* **E. Oelschläger.** (Zeits. Vereines Deutsch. Ing., 62. pp. 422–427, July 6, 1918.)—The author, in this portion of his extended series of articles upon lubricating oils, deals with the relation between viscosity and temperature. He points out that it is customary to

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carry out the viscosity test at various temperatures according to the intended application of the oil, the usual test temperature for transformer oils being 20° C., for bearing oils 50° C., and for cylinder oils 100° C. No formula or chart, however, has existed up to the present which would enable one to calculate the viscosity at any other temperature than that at which the observation was actually made.

As a result of an extended investigation of the results obtained with many oils, the author has constructed curve diagrams which overcome this difficulty. By aid of these, the viscosity of any oil can be ascertained for any temperature when one determination of it has been made. The only exceptions to the law governing the rate of change in the viscosity, with temperature variations, are : rape-seed oil, linseed-oil, and blubber-oil.

J. B. C. K.

611. *Potash from Wood Ashes.* **C. T. Edgar.** (Met. and Chem. Eng. 18. pp. 587–589, May 15, 1918.)—The crude form of potash produced from wood ashes is known to the trade as "potash first sorts" and consists of a soluble portion of wood ashes, obtained by a process of lixiviation. The salts are dissolved by soaking the ashes in water, followed by draining off through a lime-filter, after which the solution is evaporated and reduced to solids by heating. The product is usually sold in tight wooden barrels containing from 600 to 800 lbs. to the barrel, and is in the form of fused, chunky masses, having something of the appearance and hardness of stone. It absorbs moisture and will become liquid if it is exposed long enough to the air.

The equipment necessary for producing these salts is inexpensive and very simple, the usual cost of a plant being about $3000. From three or four plants doing business in the early period of the war, the number of such plants is now increased to 50 in Wisconsin and Michigan alone. Exact production figures for this district are not yet available. A representative number of plants, however, report an output ranging from 1500 lbs. to 4000 lbs. a week at each plant, but the average is closer to the smaller figure. A conservative estimate would place the production of potash salts in Wisconsin and Michigan at 8,900,000 lbs. annually, having a value of $1,170,000 at present prices.

The recovery of potash from wood ashes was quite an extensive manufacture at an earlier period, but since 1870 the wood-ash product has been largely displaced by the mineral salts from the German deposits.

J. B. C. K.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

612. *Nitric Acid from Nitrogen Oxides.* **G. B. Taylor, J. H. Capps, and A. S. Coolidge.** (Indust. and Eng. Chem., J. 10. pp. 270–275, April, 1918. Engineering, 106. p. 96, July 26, 1918.)—An account is given of an investigation carried out by the Bureau of Mines. It was first tried to absorb the oxides or peroxide in sulphuric acid of 90 % and remove it again by heat or some denitrifying agent. A mixture of sulphuric acid and chromic acid looked promising as absorbent, but the absorbent had to be used at 150° C., and the electrolytic recovery of the acids from the chromic sulphate formed proved difficult. Electrolytic oxidation of the nitrous vapours dissolved in sulphuric acid alone also failed. The authors therefore came back to the usual absorption of the vapours by water and nitric acid, making use of 5 towers, the first of which was left empty to provide ample reaction space, the others being packed, leaving the upper portions free, however. The absorption was practically complete in the first 3 towers, and little would be gained by using more than 5 towers. As the rate of feed of the nitrogen oxides was increased from 1·15 to 4 cub. ft. per min., the efficiency of the absorption decreased from 98 to 91 %, but the total yield of HNO_3 increased from 28 to 68 lbs. per 24 hours. Cottrell electric precipitators (glass tubes with an axial Pt-wire and a wire coil outside) were used to reduce the losses of acid; the precipitators acted successfully on mists, but only slightly on the finest gaseous particles. Atomising sprayers, ample reaction space, and about 5 % of oxygen excess are recommended. H. B.

613. *Synthetic Gasoline by High-tension Discharge.* **L. B. Cherry.** (Am. Electrochem. Soc., Trans. 32. pp. 345–364; Disc., 364–372, 1917. Met. and Chem. Eng. 17. pp. 465–466, Oct. 15, 1917.)—Description of a kind of petroleum cracking process conducted by passing mixtures of petroleum vapours and of hydrogen or natural gas through electrically heated iron tubes while high-frequency, high-tension currents are sent through the axial wire electrode. The hydrogen (also steam or gas) enters the still through a perforated pipe under pressure in order to facilitate evaporation. The first experiments were made with a tube 3 ft. high; the height was then increased to 10 ft. and finally to 34 ft., the tubes being carefully lagged. High-pressure (5·5 atmos.) was found profitable, but insulation and leakage troubles were too severe, so that heating up to 538° C. at atmospheric pressure was adopted. The high-frequency discharges are said to prevent the deposition of carbon and also the formation of olefines which would otherwise occur. A conversion finally of 84 % of heavy oils into gasoline is claimed, but there are no analyses, only gravity tests. The equipment (plant locality not stated) is for treating 60,000 galls. of oil per day by currents of more than 85,000 cycles per sec. and ranging from 15,000 up to 250,000 volts. Electric heating is preferred because the temperature has to be controlled. H. B.

614. *Fulton's Electric Zinc Furnace.* (Met. and Chem. Eng., 18. pp. 539–540, May 15, 1918.)—The Metallurgical Laboratories, Inc., has been experimenting for about a year and a half with the zinc-smelting process devised by C. H. Fulton, determining the proper mixtures for briquetting, also the current requirements, and the condenser designs capable of liquefy-

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ing the tremendous volume of vapour produced. At the present time the plant contains an intermittent furnace of commercial size, operating on various oxide and silicate ores. The furnace now in operation is practically that described in U.S. Pat. 1,242,337 (Oct. 9, 1917), which, together with others recently granted (1,242,339 to 41, and 1,249,061), gives a large number of details concerning the experiments. The furnace is an electric resistance furnace, consisting of a movable cylindrical steel shell, closed at the top, lined with refractory material, and the open bottom resting on a fixed base, the passages being heated by a gas flame. The dried ore, with suitable binder, is formed into briquettes which constitute the resistors, and the electric current passing through these generates sufficient heat to raise the interior to such temperature as is necessary for the reduction of the zinc compounds and the vaporisation of the metal. The finely divided zinc-bearing material (ore, blue-powder, or ashes), is mixed with pulverised coke for a reducer, and sufficient binder is added (tar or hard-coal tar pitch) thoroughly to coat the particles. The hot mixture is compressed into rods, 12 in. in diam. and 6 ft. long, at a pressure of from 500 to 1000 lbs. per sq. in. These are then pre-heated in order to coke the binder, and to drive off the hydrocarbons before distillation begins. The briquettes are properly supported during this process in order to maintain their shape; a neutral or reducing atmosphere is also essential to prevent the coke at the surface from burning and loosening into a friable layer.

In operation, the baked briquettes are assembled upon the bottom electrodes, and the top connections are made. A pre-heated retort is lowered over the whole, and the current switched on. The energy input is relatively small until the whole interior of the retort reaches a temperature of from 700° to 800° C., when the current is rapidly increased until the distillation point is reached. The products of the reaction (zinc and CO vapour in equal volumes) are drawn off in a quite pure condition through openings at the top of the base, and are discharged into a suitable condenser set near by. A complete cycle requires 5 to 6 hours, when the distillation is practically complete.

Two condenser designs are illustrated in the patents specifications.

J. B. C. K.

615. *Electric Furnaces for Forging and Annealing Steel.* **W. S. Scott.** (El. Rev., Chicago, 72. pp. 941–944, June 8, 1918. Electrician, 81. pp. 271–278, July 26, 1918.)—The difficulty in making furnaces for this type of work is to obtain a suitable resistor. If carbon or graphite is used it must be very pure, and it is difficult to obtain a sufficient quantity even if this were the only difficulty. If any slag or ashes are left from the combustion of the resistor these remain in the bed and the contamination gradually increases. If the slag is fusible a clinker forms, which rapidly extends throughout the mass, resulting in a rapid increase in resistance and failure to heat. Moreover, the temperature at the bottom of the resistor bed may become very high, for instance 3600° F., owing to the large negative temperature-resistance coefficient. Such high temperatures cause trouble with the refractories. Experiments have, therefore, been made with silicon carbide as a resistor and good results have been obtained. The temperature of decomposition of this material is above 4000° F., which is approximately 1500 deg. F. higher than the hottest temperature required at the surface of the resistor. The atmosphere is non-oxidising and, therefore, the resistor is non-consuming. Silicon

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carbide may be moulded in block form, and due to its high tensile strength the roof of the heating chamber, as well as the hearth, may be made of these blocks. The large negative temperature coefficient may be utilised in the control of the furnace temperature.

The first furnace was made up with blocks having a cross-section of 4½ in. by 2½ in. and the furnace was made for heating 50 lbs. of steel per hour to 1800° F. In the second furnace the resistor consisted of two blocks 2½ in. by 4½ in. in cross-section by 9 in. in length, connected in parallel, one over the heating chamber and one underneath. The resistors were surrounded by, and embedded in, a refractory lining made up principally of a crucible clay and a graphite mixture. Surrounding this extremely hot area were silica bricks. The resistors terminated in electrode-chimneys filled with granular graphite, into which steel terminal plates extended for the connections.

The great difficulty with fuel-fired furnaces for forging is in the uneven heating that results; with electric heating this is avoided. Similarly in electric annealing there are advantages. Uniform temperature is secured and this may be obtained and maintained indefinitely. Moreover, there is a neutral atmosphere so that the steel does not become oxidised. W. R. C.

616. *Supplying Single-phase Electric Furnaces from Three-phase Systems.* **E. Piernet.** (Rev. Gén. d'Él. 3. pp. 782–785, May 18, 1918.)—It is pointed out that single-phase furnaces are often preferred to 3-phase furnaces; the author therefore discusses in a general way the feeding of single-phase furnaces from the separate phases of a 3-phase supply. W. R. C.

617. *Electricity as an Aid to the Growth of Crops.* (El. Rev., Chicago, 72. p. 982, June 1, 1918.)—The method of applying electricity, which is described in this article, is the invention of R. D. McCreary, and differs from the customary plan followed in England, in that there is no overhead equipment required of poles and wires; and therefore the installation of the system is much cheaper. The high-frequency current used is, it is claimed, literally driven through the surface of the soil from special distributing electrodes, embedded about 6 in. below the surface, and arranged parallel to each other, and on opposite sides of the field, along the fence lines. The control of the electricity is brought about by metallically coating the seed with a finely divided non-deteriorating metal before planting, thus creating lines of low resistance. After the germination of the seed, the metallic element is deposited in the heart of the roots of the plant, thereby increasing the rapidity of growth, the volume and quality of production and inducing earlier maturity. Tests made during the summer of 1917 with corn growing on 11 acres of ground at Lombard, Tee., showed the following results:—

(1) Came up 3 to 4 days sooner. (2) Increased the germination 31 to 39 %. (3) Increased the rapidity of growth 30 to 40 %. (4) Increased the volume of stalks 35 to 40 %. (5) Increased the corn production (estimated) 30 to 40 %. 6. Increased the money value (estimated) per acre, $25 to $35.

Sugar-beets were also improved both in weight and sugar contents by the electrical treatment. The electrical equipment can be operated from any electric lighting circuit, and the cost is said to be less than 50 cents per acre. The whole installation costs less than $200. J. B. C. K.

618. *Electrical Porcelain.* **L. E. Barringer.** (Met. and Chem. Eng. 16. pp. 433–436, April 15, 1917. Paper read at a joint meeting of Am. Electrochem. Soc., Am. Chem. Soc., and Am. Soc. Chem. Ind., Feb., 1917.)—The

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paper gives a brief survey of the manufacture and composition of electrical porcelain, and of its mechanical and electrical properties. Of the latter, the following data are given: A thickness of $\frac{1}{4}$ in. will usually not puncture under 70,000 volts; $\frac{1}{2}$ in. not under 100,000 volts. (Type of electrodes not specified.) The increased dielectric strength with thickness follows roughly a quadratic law. The dielectric strength and insulation resistance fall with rise of temperature, and at 800° C. porcelain becomes a very poor insulator: in fact, the dielectric strength begins to fall at 100° C. The decrease of insulating resistance with rise of temperature is of the order 100 to 1 with a rise of 51 deg. C. The specific gravity of electric porcelain is 2·4; its coefficient of expansion 0·504 per 1 deg. C. The compression strength is given as 20,000 lbs. per sq. in., and the tensile strength 900 to 1800 lbs. per sq. in. Wet-process porcelain has a higher dielectric strength than dry-process porcelain, on account of the different method of preparing the mixture. Wet-process porcelain will not absorb over 1 % of water; dry may absorb as much as 1 % under the same conditions.

The author describes the new type of continuous kiln operating at Schenectady, which is saving 50 % of the fuel required for operating the up-draught kiln. This consists of a straight tunnel 197 ft. long, with the firing zone nearer the discharging than the charging end. At the firing zone there are grates on either side. Air for combustion is preheated by coming into contact with the outgoing cars of cooling ware. The gaseous products of combustion pass towards the receiving end of the kiln and serve to heat the incoming cars of cold ware. The temperature of burning is 1300°–1400° C. A kiln of this type is equivalent to about $3\frac{1}{2}$ of the ordinary potters' kilns of 14 ft. diameter. The kiln is a radical improvement, not only for electric, but for all, ceramic ware. J. L. L.

619. *Porcelain.* **A. V. Bleininger.** (Met. and Chem. Eng. 16. pp. 589–594, May 15, 1917. Paper read at joint meeting of Am. Electrochem. Soc., Am. Chem. Soc., and Am. Soc. Chem. Ind. Feb., 1917.)—The author discusses the different compositions for the body and the glaze of various types of porcelain, including American, and hard-fire German, Danish, French and Japanese porcelain, as well as soft porcelain.

The vitrifying effect of felspar in different percentages is shown by curves giving the porosity for the different temperature-changes. These diagrams are extremely useful in the study of the proper vitrification temperature and the point of over-firing, which results in the formation of a vesicular, spongy structure. At the same time, the general slope of the curve is indicative of the rate of vitrification. The author gives a typical hard porcelain diagram showing changes in porosity and volume when the porcelain is fired at different temperatures. Microscopic sections of American, Japanese, and German porcelain are given, showing the structure. In the American type porcelain very little sillimanite appears, and the quartz is dissolved only to a slight extent; for this reason the amount of glass formed is very much less than in the high-fired porcelain.

The author gives data of the physical properties of porcelain, such as specific gravity, mechanical strength, thermal and electrical conductivity, etc. J. L. L.

620. *Electrical Resistance of Porcelain at different Temperatures.* **R. G. Allen.** (Roy. Dublin Soc., Proc. 15. pp. 289–309, June, 1918.)—The resist-

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ance of eight samples of porcelain was investigated up to about 250° C., three methods of measurement being employed. These involved the use of (*a*) a megger, (*b*) a high-resistance galvanometer, (*c*) a 0·005-mfd. condenser, the rate of leakage of which was determined by a Kelvin multicellular electrostatic voltmeter. Over the limited temperature range investigated it was found that the specific insulation resistance σ and the absolute temperature T were related by the formula $\log \sigma = a/T + b$, due to Rasch and Hinrichsen; a and b are constants for the material under consideration, and the author suggests that these may serve to identify the origin of the porcelain. V. C.

621. *Insulating Properties of Erinoid.* **R. G. Allen.** (Roy. Dublin Soc., Proc. 15. pp. 331–358, Aug., 1918.)—Tests were carried out on different coloured samples of erinoid and also on red vulcanised fibre with the object of comparing the properties of the two materials for insulating purposes. The author finds that in the case of tubes of erinoid the specific insulation resistance is higher when unprepared than when machined; and blonde erinoid has a higher specific resistance than any of the other varieties, and higher than the red fibre tested. When dry, erinoid is a good insulator, but slightly hygroscopic, though not so much so as fibre. When its surface is not machined the resistance of erinoid depends greatly on the value of the applied voltage unless water electrodes are used. This dependence is very slight in the case of unmachined fibre either with mercury or water electrodes. But in the case of machined erinoid the resistance is almost independent of the voltage. Rasch and Hinrichsen's relation between temperature and resistance holds both for erinoid and fibre (over the range 0°–80° C.). V. C.

622. *Hysteresis Losses for D.C. and A.C. Magnetisation.* **L. Dreyfus.** (Archiv f. Elektrot. 6. pp. 437–440, 1918.)—The author discusses the results of Gumlich and Rose on the total losses in ring specimens magnetised by alternating current [Abs. 1098 (1905)]. Gumlich and Rose expressed the losses as the sum of two terms, namely: $\nu\eta B^{1\cdot6} + \nu^2 f B^2$, where $\nu =$ frequency. The first term is the ordinary hysteresis loss giving constant Steinmetz coefficient η. The second term is the eddy-current loss; f, however, is not constant, but diminishes to $B = 12{,}000$ and then becomes fairly constant. The author points out that there is no proper theoretical basis for the assumption of identity of static and dynamic hysteresis loops. The eddy-current loss being calculated, there is a further hysteresis loss which increases with ν^2. L. L.

623. *Preparation of Pure Alloys for Magnetic Purposes.* **T. D. Yensen.** (Am. Electrochem. Soc., Trans. 32. pp. 165–182; Disc., 183–184, 1917.)—The magnetic properties of metals and alloys depend largely upon the crystal boundaries, and with no impurities present between the crystals exceedingly high permeabilities and low hysteresis losses can be obtained. The addition of elements, especially silicon, which form solid solutions with iron increases the electrical resistance without affecting the magnetic properties. Cobalt and, perhaps, nickel are the only elements which do not lower the magnetic saturation value of iron. Cobalt up to 34·5 % (Fe_2Co) increases this value. The preparation of electrolytic iron on a large scale from an electrolyte containing 250 gm. ferrous sulphate, 150 gm. ferrous chloride, and 200 gm. ammonium sulphate with a current density of

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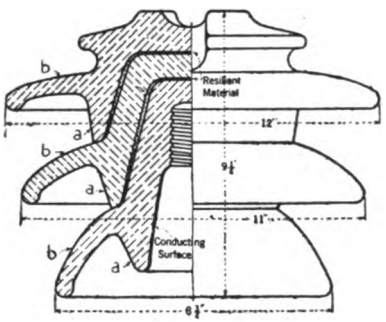
1 amp./dm.². gives a material containing 99·97 % iron and 0·01 % carbon. The preparation and composition of pure samples of Ni, Co, Si, Al, Ti, Mn, V, B, C, Mg, Ta, Zr, and U are considered. The preparation of magnesite crucibles is described together with melting and annealing furnaces and the magnetic testing equipment. [See also Abs. 1098, 1099 (1915).] F. C. T.

624. *The Design of Transmission-line Insulators.* **G. I. Gilchrest.** (Am. I. E. E., Proc. 37. pp. 571–590, June, 1918.)—This paper deals with the design of pin-type transmission-line insulators, and is concerned partly with practical and partly with theoretical considerations. The theoretical considerations have been stated in 1913 in two papers by Fortescue and Farnsworth [Abs. 487 (1913)]. The causes of failure of insulators are first stated, and the author then proceeds to the consideration of the dielectric field of several theoretical designs produced out of commercial porcelain. The insulator was fixed so that the plane of the dielectric field was horizontal. A piece of fullerboard was fitted over a half section of the



insulator in this plane: finely divided asbestos was then sifted on the fullerboard: the voltage was then applied and the fullerboard gently tapped. Photographs were then taken, and several of them are reproduced. From these results a new type of design is evolved, of which the appended Fig. gives an example. In this case, surfaces *a* conform to the flow-lines of the electrostatic field: surfaces *b* of the rain sheds conform to the equipotential surfaces: lines of mechanical stress are parallel to the electrostatic flow-lines, the leakage resistance per shell is about equal, being increased gradually from the head to the centre shell: there is approximately equal capacity per shell. Comparisons were then made with older designs, and tests were carried out. The matter cannot here be considered in detail, but the author concludes that the following advantages, among others, attach to his proposed form of design:—With dry insulators, the corona and static formations are practically limited to the tie wire and line wire; with wet insulators, there is no corona or static formation up to the flash-over voltage. The leakage resistance per shell is increased gradually from the head to the centre shell. The voltage distribution per shell will be equal when the insulator is clean and dry, and should be approximately equal under all operating conditions. The resistance of the insulator to side pull for a given weight and given electrical strength is relatively high. The design of the individual shells is such that, when they are tested before assembly, the surface conforms to the electrostatic flow-lines *a*. When hit by stones or bullets, the insulator sheds do not break beyond the surface *a*.

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The paper contains a large number of photographs showing designs, and the results of tests of various kinds. W. H. S.

625. *Protection from Flashing for D.C. Apparatus.* **J. J. Linebaugh** and **J. L. Burnham.** (Am. I. E. E., Proc. 37. pp. 617–628, June, 1918.)—The authors have attempted to construct a circuit-breaker that can operate within the time required for a commutator bar to pass from one brush to another, that is, within one half-cycle: this time is about 0·007 sec. in most commercial machines. It was decided to use the principle of a latch, heavy spring and series tripping coil. A photograph is given of this type of apparatus. Very quick tripping, rapid acceleration of contacts, and a sufficient number of amp.-turns in the magnetic blow-out were necessary. A series blow-out coil had to be used with 150,000 amp.-turns at the max. current. The moving parts must be as light as possible, with a spring compressed to about 8000 lbs. The breaker was tested on a 2000-kw., 3000-volt d.c. synchronous motor-generator: and a record is reproduced, which shows that the device started to insert resistance in 0·008 sec., and that the load on the machine was reduced well below the flashing-point in 0·2 sec. It was found that this speed would not protect on the most severe short-circuit; barriers were therefore designed and used, as shown in one of the photographs. The most successful kind of barrier consists in a close-fitting box of fireproof insulating material, surrounding each set of brushes, and having a small clearance between the box and the commutator. On the side of the box towards which the commutator rotates after leaving the brush is a V-shaped scoop; radially above the scoop, about 1 in. apart, are 2 metal screens, one coarse and one fine mesh, through which the arc is forced and cooled. A moderate amount of material is needed to give the necessary thermal capacity to prevent an arc from passing beyond a screen of this kind. Some of these breakers have been in use for a year on the Chicago, Milwaukee, and St. Paul Railroad, and have proved successful. Hosegood has suggested the use of silver fuses for limiting the current: oscillographic records show that very good results can be obtained in the matter of speed. The uses of reactors are also considered. J. F. Tritle has suggested another form of circuit-breaker: this is essentially a contactor having a laminated structure with electric holding coil and series bucking coil, so that it opens when the load reaches a value sufficient to offset the amp.-turns of the holding coil. A photograph of this apparatus is given; it has been latterly used also with success on the railway. The paper contains a large number of photographs, some of which show the phenomena on short-circuit when the machinery is protected as described. W. H. S.

626. *Meter Report of the Canadian Electrical Association.* (Canad. El. News, 27. pp. 45–48, July 1, 1918.)—The most interesting of the new meters mentioned are as follows: Type CC single-phase watt-hour meter (Canadian Westinghouse Co.) for sizes from 5 to 20 amps. The 60-cycle meter load-curves show a variation of 0·2 % from no load to 75 % overload, and a drop of 0·8 % from 75 % to 100 % overload. The 25-cycle meter gives load curves which vary about 0·8 % from no-load to full load with a drop of 1 % at 50 %, and 2·2 % at 100 % overload. There is little change in accuracy for voltage variations 10 % above and below normal. The British Westinghouse Co. has developed a series of graphic, strip recording meters of the dynamometer type for alternating and direct current. The principal change in switch-

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board meters has been in the direction of smaller dimensions so as to decrease the amount of switchboard space required.

Expensive maximum-demand meters are justified in the case of large consumers, but initial expense must be kept down in the case of small consumers. Definite time maximum-demand meters now on the market are mostly open to the objection that the actual max. demand is not recorded if it occurs in such a manner as to be "split" by the time period. The nearer the load factor is to 100 %, the more accurate is the usual max. demand meter, but if the max. demand occurs only a few times a month the company is liable to lose 50 % of its revenue. The heat-storage max. demand indicator described in Abstract 251 (1918) has important advantages but its use would necessitate rearrangement of rates and contracts.

Central stations may handle increased load without extra line capacity by improving the power factor of consumers' loads. The Westinghouse R. H. thermal meter takes account of both the wattless component and the power consumption. The report describes various methods of determining power factor. Power-factor recorders and indicators are not satisfactory; at least 60 % full load is required before high accuracy is obtained and the accuracy is lowest at low points on the scale. The simplest and most obvious method of determining average power factor is by using either two single-phase meters or one single-phase meter and a polyphase meter which gives the total energy consumption. This method assumes balanced loads. An easy method of determining power factor is to read off its value from a curve between power factor and ratio of watt-hour meter readings.

When the load is badly balanced and in cases where power is sold on a max. demand basis, it is necessary to use equipment which will give the average power factor of an unbalanced load, or the power factor at the time of peak. One method (described fully in the original) is to connect a standard watt-hour meter or graphic wattmeter to read proportionally to the wattless component of the load. This equipment used in connection with ordinary apparatus giving true power or energy, offers a means of obtaining power factor at peak.

A method applicable to watt-hour meters and indicating wattmeters is to "overlag" the potential element of the meter, so that the angle between unity-power-factor current flux and the potential flux will be more than 90°. This may be accomplished by an external reactor in the potential circuit of the meter or by using the compensating coils of the commercial type of meter. Assuming a contract power factor of 85 %, the meter is set so that the registration is as nearly as possible 85 % of the kv.a. at the actual operating power factor.

Taking all factors into consideration, probably the best method is to use standard wattmeters or watt-hour meters registering proportionally to the wattless component. R. E. N.

627. *The Oxide-film Lightning Arrester.* **C. P. Steinmetz.** (Am. I. E. E., Proc. 37. pp. 551–560, June, 1918. El. World, 71. pp. 1868–1870, June 29, 1918.)—A brief history is given of the development of lightning protection in the three types of electric circuits: communication circuits, power circuits of negligible electrostatic capacity, and high-power circuits containing distributed capacity and inductance and capable of electric oscillation. The problems to be solved are: discharging over-voltage to ground; opening the power current which follows the discharge; and preventing power current

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from following even for part of a half-wave. A spark-gap to ground discharges over-voltage; a multi-gap arrester with non-arcing metallic electrodes opens the circuit at the end of a half-wave of current; and the "counter e.m.f." type of arrester (*e.g.* aluminium cell and oxide-film arresters) interrupts power-current flow practically instantaneously. The oxide-film arrester is as effective as the Al type in dealing with recurrent discharges in high-power systems, and has the great advantage over the electrolytic type that it contains no liquid and does not need re-forming every day [see C. Field, Abs. 564 (1918)]. The oxide-film arrester is maintained automatically in operating condition, and if needs be it will discharge continual disturbances, every half-wave, for ½ hr. or even several hours before it is endangered by the accumulated temperature-rise due to these discharges. The dielectric film on the electrodes of the oxide-film arrester is re-sealed by reduction of the requisite tiny amount of lead peroxide: there is no action corresponding to that which dissolves the film in Al cells.

The multi-gap arrester short-circuits at the first oscillation and maintains the "short" for the rest of the half-wave; if the oscillations are recurrent, such as those due to an arcing ground on a transmission line, the first oscillation in the next half-wave re-establishes the short-circuit through the arrester, which is therefore subjected to practically continuous short-circuit and is destroyed if the disturbance continues for any appreciable time. The valuable characteristic of Al and oxide-film arresters is that they do not short-circuit the machine-current even for a fraction of a half-wave: it is merely the over-voltage which is discharged.

In the latest oxide-film arresters the electrodes are of sherardised iron which is spun over the porcelain separating ring. Provided that the sphere-gap and the arrester cells are protected against rain, the arrester can be located out of doors. The author gives typical oscillograms showing the action of the oxide-film arrester under a recurrent oscillation, and under a single high-power impulse produced by opening a highly inductive circuit (d.c. traction motor). Protection against high-frequency disturbances of voltage lower than required to bridge the series gap is obtained at present by a capacity discharge path connected permanently between circuit and ground. ground.

The author suggests that an arrester will be developed which needs no spark-gap but is permanently shunted across the circuit and is thus able to deal not only with over-voltages, but also with steep wave-fronts and high-frequency oscillations of lower than circuit voltage. Such an arrester would give universal protection. [See Abs. 564 (1918).] R. E. N.

628. *Instrument for the Analysis of Wave-shapes.* **A. Roth.** (Archiv f. Elektrot. 6, pp. 859–876, and pp. 888–406, 1918.)—Resonance methods have been applied to the oscillograph to enable wave-shapes to be analysed, but this method involves the difficulties of use of the oscillograph. The instrument here described enables the magnitude of harmonics to be obtained directly by a reading on a dynamometer. The method of measurement is simple, no rotating parts are required, and the apparatus is suitable for use on high voltages. The principle of action is based on the properties of parallel oscillating circuits of different natural frequencies. After making a mathematical investigation of the characteristics of such circuits, the instrument is described. It consists of a dynamometer with two fixed coils and one moving coil. One of the fixed coils is connected across the line in series with a non-inductive

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resistance; the second is connected across the line in series with a circuit consisting of two parallel oscillating circuits with natural frequencies greater and less than that of the harmonic that is being sought; the moving coil is connected across the line in series with an oscillating circuit adjusted to the frequency of the harmonic. The two fixed coils are differential in their action. Under these circumstances, if the constants of the various circuits are suitably chosen, the instrument responds only to currents of the frequency of the harmonic to be measured, and its reading will be proportional to the magnitude of that harmonic. In the second part of the paper the details of the practical application of the method are considered and the precautions necessary to eliminate errors due to the presence of harmonics other than the one being measured. The dimensions and construction of the instrument are given and the disturbing effects calculated that are introduced by the use of iron in the magnetic circuit, the self- and mutual inductions of the coils, and by the change of the resistances of the coils owing to temperature variations. Lastly it is shown how the natural frequencies of the oscillating circuits should be adjusted. A number of wave shapes are analysed by the instrument and by a mathematical method and the results are found to be in good agreement. The instrument gives accurate values for harmonics that have a magnitude greater than 1 to 1·5 % of the fundamental. It is a drawback of the method that the phase relations of the harmonics are not determined. A. J. M.

629. *Calorised Iron as an Element for Thermo-couples.* **O. L. Kowalke.** (Am. Electrochem. Soc., Trans. 32. pp. 215–220; Disc., 220, 1917.)—The author compares the thermo-electromotive force of couples of "calorised" iron-constantan with that of "uncalorised" iron-constantan.

"Calorising" is a process which results in the production on the surface of the iron of a rich aluminium alloy [see Abs. 997 (1915)]. The coating practically prevents oxidation below 1000° C.

In these experiments one sample of calorised iron gave the same e.m.f. as uncalorised iron up to 1000° C. on repeated calibrations. A sample of calorised iron from another source gave slightly different potentials until it had been heat-treated at 800°, after which it gave similar results to the other calorised wire.

The author concludes that calorised iron may be a suitable material to replace iron in the iron-constantan combination, because it has the same e.m.f. and constancy as uncalorised iron, but has a much longer life. Also that a thin coating of calorising is effective, and is to be preferred to a thick coating because of the greater liability for a thick coating to flake off on bending. The calorised wire should be a fairly heavy one, to avoid bending and to provide a sufficiently large iron core inside the Fe-Al coating. E. G.

630. *Generation of High-tension Direct Current for Testing Cables.* **J. Sarolea.** (Rev. Gén. d'El. 4. pp. 4–8, July 6, 1918.)—It is becoming increasingly difficult to test networks of cables at the prescribed a.c. voltages, as the volt-amp. capacity of the testing transformers usually available does not suffice for the growing voltages and sizes of the networks. Furthermore, resonance and excess voltages are to be feared when applying step-up transformers to long sections of unloaded cables. The author describes a method of obtaining high-tension direct current by the use of specially designed Fleming valves fed by alternating current. The valves are manufactured by the

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Société des Tubes à Vide Bocuze et Cie, of Lyons, and have a high capacity—0·2 to 0·25 amp. with a voltage drop of 1500 volts. Photographs of these tubes are given. The tungsten anode is in the form of a cylinder of 15 mm. diam. and 80 mm. length. The vacuum is of a high order—several hundredths of a micron mercury pressure. The temperature of the anode should be kept below 1500° if inverse current is to be prevented. The cells are connected up in pairs, so as to utilise both half-waves of the a.c. As an example of the application of the method, connections are shown for the testing of a 3-phase cable with pressures up to 15,000 volts. One core of the cable is connected to the sheath, earth and one pole of a high-tension transformer; the other pole of the transformer is connected through a resistance of 500,000 ohms to the other two cores of the cable, valves being interposed between the resistance and each core, and the valves being connected in opposite directions. The time required for charging up the cables to different fractions of the final voltage is calculated. A. J. M.

631. *Current Capacity of Copper Bus-bars.* **F. M. Billhimer.** (Elect. J. 15. pp. 94–96, March, 1918.)—The rise of temperature of copper bus-bars depends greatly on the spacing of the conductors. The usual practice of specifying current densities is not sufficient, and it is better to state the permissible temperature-rise, as this depends on the size, shape, and spacing of the conductors.

In the case of direct current it is shown that the current that can be carried by a bar of a certain depth does not vary proportionally to the thickness of the bar, and furthermore the current-carrying capacity depends on the relative position of different bars carrying the current. The capacity of a rectangular bar varies directly with the width, but not directly with the thickness. When the bars are used in multiple, the use of several thin bars instead of one thicker one will often mean a considerable reduction in the temperature-rise. The dependence of the temperature-rise of conductor on the spacing between individual bars forming a multiple conductor, and for various spacing between the outgoing and return circuits, is shown as the result of tests made, curves being plotted showing the temperatures of the inner and outer conductors with the different bar spacings. Some of these tests are carried out with alternating currents in which the conditions are somewhat complicated by the introduction of skin and edge effects.

A. J. M.

632. *Self-inductance of Short Reactance Coils.* **H. B. Dwight.** (El. World, 71. pp. 800–802, Feb. 9, and pp. 1078–1079, May 25, 1918.)—In the first article the author gives a formula for calculating the self-inductance of long coils. In the second article he gives a similar formula for short coils, *i.e.* coils in which the length is less than the mean diam. The formulæ for the two cases are somewhat lengthy, but their use is simplified by the use of curves (now drawn for short and long coils), from which the inductance in henrys may be read off for various values of the ratio of the length to the diam., separate curves being drawn to correspond to different values of the ratio of the thickness of the winding to the diam. A. J. M.

633. *Repulsion and Mutual Inductance of Coils.* **H. B. Dwight.** (Elect. J. 15. pp. 166–168, May, 1918.)—Formulæ and curves are given from which the mutual inductance of coaxial cylindrical coils of equal diam. and depth

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of winding is obtainable. From the mutual inductance the repulsion between the currents is calculated. The results are applied to coils of unequal as well as equal length.

The mutual inductance of the coils is given as the algebraical sum of a number of self-inductances which are calculable from formulæ previously given by the author [see preceding Abs.] and the mutual inductances can be easily obtained from curves for different values of the ratios between the coils and their mean diam. for different values of the ratio of the length to the diam. of the coils.

The force of repulsion between the coils is proportional to the space differential of their mutual inductance and is calculated on this basis and obtainable from a series of curves similar to the one just referred to.

The results obtained by calculation are compared with some actual test figures and found to give good agreement. A. J. M.

634. *Detective and Protective Devices for Cables.* (El. Rev. 82. pp. 604–606, June 28, 1918. Electrician, 81. pp. 204–205, July 5, 1918. Abstract.)—The firm of Glover and Co., Ltd., has introduced a cable which contains an added subsidiary or test conductor in the form of a spirally-wound copper tape, surrounding the insulated conductors and insulated from the lead sheath by a thin layer of hygroscopic insulating material. Any external injury must therefore damage the test conductor before the main insulation is affected. This test cable has an insulation resistance of the order of 50 to 100 megohms per mile: when tested, it will give an indication as to the integrity of the lead covering or other waterproof sheath. A statement is given as to the proposed tests and methods of carrying them out. There is also a diagram of suitable connections for testing purposes. W. H. S.

635. *Arc Welding of Mild Steel.* **O. H. Eschholz.** (Elect. J. 15. pp. 247–250, July, 1918.)—Of the various arc-welding processes the Slavianoff, or metal electrode process, has the widest use. In this method the metal rod serves both as electrode and weld filler. On striking the arc the filler rod automatically attains the fusion temperature and is deposited in a molten state on the hottest section of the weld surface. Movements of the surrounding air tend to remove the protecting screen of incandescent gaseous compound as rapidly as it is formed, making it necessary for the welder to manipulate the electrode in such a manner that max. protection by envelopment of arc flame for both arc stream and electrode deposit is continually secured. By maintaining a short arc and inclining the electrode at the correct angle with the work this condition is automatically obtained.

In the Table analyses of a few characteristic electrodes are given as well as the metal deposited after having passed through the arc. As a whole the action of the atmospheric gases is to refine the vaporised metal, decreasing such constituents as C and Mn. The increase, shown in some deposits, of P, S and Si content is attributed to their absorption by the hot filler metal from the shank metal. The inconsistency in the degree of refinement shown by the hot roller electrode is due to its characteristic of depositing in large globules, rather than in a spray of small globules, thereby exposing a smaller area to oxidation for a given volume of transferred metal. However, this action tends to produce incomplete fusion.

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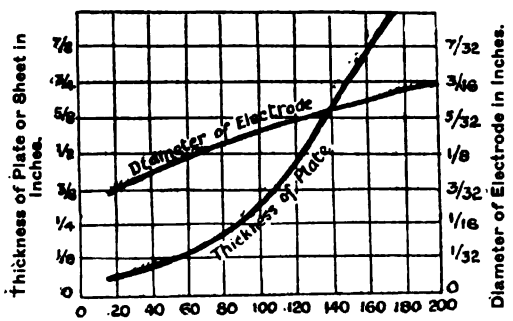
CHEMICAL ANALYSES OF ELECTRODES AND METAL DEPOSITED IN WELD.

Electrode.	C.	Mn.	P.	S.	Si.
Roebling	0·16	0·56	0·082	0·024	0·016
Roebling deposit	0·05	0·18	0·081	0·086	0·011
Coated	0·07	0·008	0·051	0·044	0·011
Coated deposit	0·08	0·021	0·042	0·046	0·058
Norway	0·049	0·021	0·025	0·007	0·08
Norway deposit	0·05	0·018	0·020	0·015	0·011
Hot-rolled steel	0·13	0·50	0·012	0·045	0·011
Hot-rolled steel deposit	0·14	0·14	0·012	0·039	0·011
Cold-rolled steel	0·11	0·72	0·097	0·123	0·011
Cold-rolled steel deposit	0·05	0·11	0·086	0·072	0·011

The extending use of arc welding makes it desirable that the constituents of a weld should be better controlled. Refractory tubes and asbestos coatings have been suggested, but the author is of opinion that better possibilities are offered by the development of an electrode which generates, during operation, an atmosphere of inert, permanent gases enveloping the arc.

The fusion obtained at the weld surface and in the body of the filler is determined by the scarf angle, arc current and electrode diam., as well as by arc length. The correct angle for scarfing abutting thick sections is 90°, spacing the sections $\frac{1}{8}$ in. apart. Approximate values of arc currents and electrode diams. for welding steel plates are shown in the Fig.



ARC CURRENT IN AMPS.

The effect of the heating upon the structure of the metal is less marked as the carbon content decreases. Since the largest field for arc welding is in the welding of mild steel, considerable latitude is permissible in the degree of heat treatment without appreciably affecting the physical characteristics of the original metal. This is shown by the following results of tests on five specimens of mild steel, arcs being struck from four of them so as to obtain different degrees of heat treatment, the fifth being untreated.

Test Piece.	1	2	3	4	5
Ultimate tensile strength, lbs. per sq. in.	49,200	49,100	48,400	48,600	49,850
Percentage elongation	43	41·7	41·8	44	40

The article is accompanied by a number of photomicrographs showing the sequence of metallographic structures on passing from the original metal through the fusion zone to the deposited metal. R. J. W.-J.

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636. *Automatic Fire Extinguisher for Transformer and Oil-switch Chambers.* K. Perlewitz. (Elekt. Zeits. 39. pp. 209–210, May 23, 1918.)—In conjunction with the Salzkotten Works for explosion-proof containers, the firm of Siemens and Halske have developed an automatic fire-extinguishing equipment for use with transformer or oil-switch chambers. A thermally sensitive device in the chamber to be protected closes a relay circuit when the temperature in the chamber exceeds a predetermined limit. The effect of this is that a tank of sulphuric acid is emptied into a potassium carbonate solution and the CO_2 liberated is carried by a pipe line to the chamber where fire has broken out. The chamber is filled quickly with CO_2 and the fire is stifled. At the same time an alarm bell (or bells) is rung, the ventilating chimney in the roof and the oil outlet in the floor of the chamber are closed and valves in the CO_2 pipes leading to the chamber affected are opened.

The actuating device may be a U-shaped bi-metallic strip or a U-tube closed at the ends, partly filled with mercury and having quite different thicknesses of glass in the two limbs. The circuits are so arranged that any defect is announced automatically without operating the extinguisher. A single gas generator may serve a number of chambers. The generator tank is lead lined and contains, above the potash solution, an eccentrically pivoted tank filled with sulphuric acid. The outlet apertures are small enough to prevent too rapid generation of gas and they are closed normally by ball valves which prevent the acid from absorbing moisture from the atmosphere. About 40 cub. m. of CO_2 can be generated in from 2 to 3 mins., and this quantity suffices to extinguish combustion in a space of 100 cub. m. content. An extinguisher of this capacity is installed in the Sterkrade station of the Gutehoffnungs Mine, where there are 6 transformer cells and the arrangement of piping is such that one cell on each side of the one in which fire originates is filled with gas as a precautionary measure. R. E. N.

637. *Electric Thermal Storage for Heating Rooms.* (Schweiz. Elektrot. Verein, Bull. 9. pp. 119–128, June, 1918.)—The article is based on the work of the Commission for Heating and Cooling Apparatus, concerning the possibility of storing heat for room warming by utilising surplus energy from hydro-electric stations during night hours when the demand for lighting and power is comparatively low.

The first point to be decided in room-heating is the requisite power expenditure. Much depends on the window and exposed wall area, heat transmission coefficient and external temperature, but the Commission consider that average requirements are met by the continuous (day and night) expenditure of energy at the undermentioned rates, assuming that the heater gives out all its energy inside the room: Average winter conditions, 30 to 40 watts per $m.^3$; coldest winter conditions, 40 to 60 watts per $m.^3$. If the heater is in service for only 8 hours during the night, the total energy expenditure during that time must be at least as great as that during 24 hrs. in the case of a continuous heater: *i.e.* the power expenditure should be 90 to 120 watts per $m.^3$ under average winter conditions and 120 to 180 watts per $m.^3$ under severe conditions. A lower allowance is often permissible in workshops owing to the fact that machinery and manufacturing processes contribute to the heating. A direct-acting electric heater may be light, portable, and comparatively cheap, but one which is to store heat developed at night for use during the day must necessarily be heavy, large, and relatively expensive. Towards the end of the heat-storing period a large

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proportion of the energy input is radiated at once. The max. surface temperature during this period should never exceed 120° to 140° C. and had better be not more than 100° C. For the stone or metal surfaces generally employed the max. rating should not exceed 10–16 watts per dm.^{2} (6 to 10 cm.^{2} per watt). If the heater is to "charge' for 8 hrs. and "discharge" for 16 hrs. it will need an input of 45 to 125 watts per m.^{3} of room space under average winter conditions. At the end of the charging period from 70 to 80 % of the power input is being dissipated from the surface of the heater, and if the latter is not to roast dust and provide an unhealthy dry heat, its surface must be from 120 to 800 dm.^{2} in the case of a heater for a 40 m.^{3} room ; 150–875 dm.^{2} for 50 m.^{3}; 180–450 dm.^{2} for 60 m.^{3} ; 225–560 dm.^{2} for 75 m.^{3}. Storage heaters built hitherto have generally had a surface of 85 to 160 dm.^{2} or 200 dm.^{2} at most, and have therefore been unsuitable for rooms larger than 40 m.^{3}.

If P be the kw. required continuously to maintain the desired room temperature (viz. 25 to 50 watts per m.^{3}), the charging power required when working with 8 hrs. charge and 16 hrs. discharge is at least $P_1 = 8$ P. The energy Q_c actually stored during the charging period must be such that Q_c/P is not less than the actual discharge time T. Methods are given in the full report for the determination of all characteristics of a storage heater from simple temperature measurements. Data are given to show that most of the heaters built hitherto have insufficient storage capacity, owing to inadequate dimensions and mass.

The max. temperature at which the heating elements may be worked is : 400° C. for iron; 600° C. for nichrome and constantan; and 900° C. for silundum bars. The max. internal temperature of the material is that of the heating elements and the mean effective temperature range of the storage material is 180–200° C. using iron, 280–320° C. using constantan, and 450° using silundum ; the lower figures apply to solid stone and the higher to sand or powdered storage medium. Sp. gr. : 2·5 for steatite, etc.; 1·1 for sand. Specific heat : 0·22 for steatite ; 0·21 for sand. Max. thermal storage 150 to 185 kg. cals./dm.^{3} (175 to 215 watt-hrs.) for steatite, etc.; 60 to 75 kg. cals. (70 to 80 watt-hrs.)/dm.^{3} for sand, etc.; according as iron or constantan elements are used. If sand be used in direct contact with silundum at 900° C., the storage is about 100 kg. cals. (120 watt-hrs.)/dm.^{3}. On the basis of these figures, rooms from 40 to 75 m.^{3} in content need heaters which absorb 3 to 5 kw. during charging and occupy 60 to 200 dm.^{3} for steatite and constantan, 75 to 360 dm.^{3} with iron wire; 150 to 550 dm.^{3} with sand and constantan, 180 to 640 dm.^{3} with iron wire.

Stone is more convenient than metal as storage material and suitable kinds give a value of $c\gamma$ (sp. heat × density) between 0·4 and 0·68, the latter figure being reached by steatite and serpentine. Good steatite is a very suitable material, but there are other stones for which the product $c\gamma$ and the thermal conductivity k at high temperatures should be determined. The Commission will publish later the result of the researches now in hand. For various sands, $c\gamma$ appears to lie between 0·2 and 0·4 ; on the other hand, sand is cheap and easily handled, and good thermal contact is secured with the heating element. R. E. N.

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GENERATORS, MOTORS, AND TRANSFORMERS.

638. *An A.E.G. 55,000-kw. Turbo-generator.* (Elekt. Zeits. 39. pp. 188–189, May 9, 1918.)—Leading particulars are given concerning a turbo-generator of 60,000 kv.a. now being built by the A.E.G. for the large power station of the Rhenish-Westphalian Electricity Co. This station is to B. Goldenberg's designs and is situated in the brown-coal area near Cologne ; a second similar 60,000-kv.a. machine will be added, so that including six 15,000-kw. sets, the total plant capacity will be 200,000 kw. The new machine yields 55,000 kw., 7000 volts 3-phase at 1000 r.p.m. with 220-volt excitation. The turbine is supplied with steam at 12 atmos. gauge pressure, superheated to 325°C., and condensing water at 27° C. The generator and turbine are each within a single housing. The turbine weighs 250 tons (rotor 49 tons), and the generator 225 tons (rotor 106 tons) : total 475 tons.

The turbine has 10 wheels, from 3400 to 3800 mm. in diam., corresponding to circumferential speeds from 180 to 200 m./sec. The blades had to be made from nickel-free steel, hence the lower ends of the longer blades had to be machined out of the solid. The generator rotor is 2200 mm. outside diam., corresponding to a peripheral speed of 115 m./sec. Including the bearing, the rotor is 9 m. long, and owing to its great size it had to be built up from a number of plates assembled on the shaft. Individual plates were tested up to 2000 and 2400 r.p.m. and the complete generator rotor was tested at the works up to 1500 r.p.m. ($1\frac{1}{3}$ times normal speed). The bearings of the machine are 600 mm. in diam., corresponding to a speed of 32 m. per sec. (47 m./sec. during the speed test).

Following the usual A.E.G. practice, the set has 8 bearings, the middle one being built as a double bearing in view of the great load to be carried. A rigid flange coupling comes between the two parts of the double bearing and is also fixed as regards axial movement, so that expansion in the turbine casing proceeds from this point as origin ; the live-steam inlet is accordingly provided with a suitable degree of freedom. The turbine casing is carried merely by the centre and forward bearings, and is therefore free to expand and contract. The whole set is carried by massive ferro-concrete foundations. Two condensers are provided, each of 3000 m.^{2} cooling surface. Each condenser weighs 100 tons, and, apart from the water chambers, is divided into four sections for ease of transport. The exhaust connections from the turbine are 2400 mm. in diameter. The present form of the turbine and the arrangements made for expansion, etc., are said to be the result of numerous tests on models of component parts. R. E. N.

639. *Sudden Short-circuits of Alternators.* **N. S. Diamant.** (El. World, 71. pp. 1126–1128, June 1, 1918.)—The author discusses practical methods of determining the different short-circuit constants for sudden single-phase short-circuits of alternators.

From oscillograms of the short-circuit current and voltage and of the field current the values of the damping factors α and β of the field and armature of the alternator are determined by graphical methods. For this purpose curves are drawn through the loci of the maximum and minimum values of the armature current, and the ratio of the distances between the upper and lower

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loci at the times of consecutive maximum and minimum values of the current is equal to $\epsilon^{\alpha\pi}$. The mean curve of the upper and lower loci is then constructed, and the ratio of the intercepts between the ordinates reckoned from the zero line and the mean curve at consecutive values of the positive and negative maxima of the armature current is equal to $\epsilon^{\beta\pi}$. From these relations the values of α and β can be obtained.

The field damping curves may also be used to obtain the values of α and β. Curves are drawn as before through the maximum and minimum points of the oscillogram representing the variation of the field current, the mean curve is again constructed and $\epsilon^{\alpha\pi}$ for the field circuit is given by the ratio of the sums of the heights of the upper and lower loci above the steady value of the field current, taken at consecutive maximum and minimum values of the field current. The value of $\epsilon^{\beta\pi}$ is given by the ratio of the distances between the mean and lower curve at consecutive maxima and minima of the field current.

The latter method, using the field oscillogram, gives the values of the damping factors independent of the time at which the short-circuit is made, whereas the former method, using the armature oscillogram, fails if the short-circuit is made near the max. value of the e.m.f. wave.

A table for the values of α and β shows that, for alternators ranging from 700 to 15,000 kv.a., α varies between 0·01 and 0·08, while β varies between 0·07 and 0·044, whence it is concluded that it may be justifiable to give representative average sudden short-circuit characteristic curves of decaying armature currents to cover modern alternators of normal design. Such curves would be useful for making the selection of oil circuit-breakers suitable for any given case.

One of the important conclusions arrived at is that the transient armature and field currents are affected only indirectly by the field excitation existing at the instant of the sudden short-circuit, and depend directly upon the difference of the flux before and after the sudden short-circuit takes place.

A. J. M.

640. *Mechanical Design and Specification of the Turbo-alternator Rotor.* **S. F. Barclay.** (Inst. El. Eng., J. 56. pp. 472–490; Disc., 490–516, July, 1918. Abstracts in El. Rev. 82. pp. 295–296; Disc., 296–298, March 29; 319–320, April 5, and pp. 357–358, April 12, 1918. Electrician, 80. pp. 793–794, March 22, and p. 806; Disc., 806–807, March 29, 1918.)—This paper, together with the discussion, constitutes a fairly complete treatment of the questions which arise in connection with the mechanical design of the turbo-alternator rotor. It is not possible to go into details in this abstract: for full particulars, the paper with its many drawings should be consulted. An abstract of the author's specifications for a solid forged rotor may, however, be given.

The rotor forging should be of high-grade carbon steel, annealed after forging, and oil-treated after rough turning. The forging is to be preferably in a single piece, but if too large for a single forging, a hollow cylinder is to be forged on a mandril, and is to be shrunk on a through shaft. Test pieces are to be cut from the end of the shaft, from the periphery of the rotor in a tangential direction, and from the end of the core in a radial direction. The yield-point, ultimate strength, elongation, and contraction of area are to be determined. The stresses at a speed 20 % above normal are not to exceed 50 % of the yield-point. The max. combined torsional and bending stress in the neck of the journal is not to exceed 7½ % of the yield-point of the material.

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The end bells to be of high-grade nickel-chrome steel, tested as before : in addition, a test-piece is to be notched and broken by impact and the fracture examined. If in a single piece, the end bell is to be a good press fit on the shaft and is to be positively driven and free from axial movement. The slot insulation is to be of micanite reinforced with non-hygroscopic material : total thickness not less than 0·06 in. The insulation between the turns to be not less than 0·01 in. of pure mica. The end windings to be insulated from the end bells by micanite not less than 0·05 in. thick, reinforced by non-hygroscopic material. The end windings to be effectively wedged to prevent movements. The slip-rings to be of carbon steel forgings, with 0·4 to 0·6 % carbon. The rings to be heated electrically for shrinking on the shaft. The connections from the windings to the slip-rings to be built up of copper laminations not more than 0·01 in. thick. The connectors are to be insulated with moulded or flexible micanite, and to be securely held against centrifugal force. The end bells should be capable of being removed without disturbing other parts. The fan blades to be of substantial thickness, and to be of oil-hardened boiler plate or oil-treated nickel-chrome steel plate. A schedule of particulars of the nature of mechanical details and tensile properties of the materials, should be furnished by the makers.

The author is of the opinion that the solid rotor is very much to be preferred to the laminated rotor. W. H. S.

641. *Armature Reaction of Polyphase Alternators.* **F. D. Newbury.** (Elect. J., 15. pp. 106–109, April, 1918.)—The armature reaction is studied by carrying out a graphical combination of a trapezoidal main field and a stepped armature field with steps corresponding to the position of the slots, and having the same shape as the space distribution of the armature amp.-turns. Diagrams are drawn for successive values of the fluxes at different periods in a cycle. These show that while the shape of the resultant field varies, the total flux remains practically constant. The investigations are extended to the case of various power factors. A. J. M.

642. *Armature Reaction of Single-phase Alternators.* **F. D. Newbury.** (Elect. J., 15. pp. 156–162, May, 1918.)—Similar investigations [see preceding Abs.] are carried out for the armature reaction of single-phase machines, and it is shown that the effects of armature reaction on the generated voltage are of the same nature as in the polyphase alternator. A. J. M.

643. *Variation of Alternator Excitation with Load.* **F. D. Newbury.** (Elect. J., 15. pp. 253–257, July, 1918.)—The voltage drop of an alternator on load is due to armature reaction, reactance drop, and resistance drop. The effects of these are examined, and it is shown how the first two may be separated by a graphical method applied to the no-load and full-load saturation curves. The dependence of the voltage drop on the power factor of the load is explained. A. J. M.

644. *Reactance of Synchronous Machines.* **R. E. Doherty** and **O. E. Shirley.** (Am. I. E. E., Proc. 37. pp. 821–908, July, 1918.)—Equations are given for predetermining the armature self-inductive reactance of synchronous machines. Calculated and test values are tabulated for 138 machines. The effective reactance of a 3-phase winding is increased by mutual induction between the phases to a value 50 % greater than the single-phase

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reactance of one winding. In single-phase machines the reactance varies during the cycle, but in Y-connected 3-phase machines this pulsation of the reactance disappears. In the case of sudden short-circuits the current is limited, not only by the armature reactance, but also by a combined self-induction of the field and armature circuits, termed the "transient reactance." In order to trace out the physical causes of this effect the field leakage fluxes of a number of different polar shapes are experimentally measured by the use of iron filings. The calculated transient short-circuit currents obtained by the methods proposed in the paper are compared with oscillograms for 11 different machines. The inclusion of the field self-induction reduces the calculated short-circuit current by about 50 %. It is shown that there is an appreciable rise in the flux at the bottom of the pole on short-circuit, amounting to 30 or 40 % of the normal flux; this accounts for the variation of the field attenuation factor after a few cycles from the time of short-circuit. Appendices refer to the effect of harmonics in the no-load flux wave, and to the calculation of the armature reaction of salient-pole machines, taking into account the variation in reactance. A useful bibliography is included. A. J. M.

645. *Limits to Alternator Voltage.* **F. D. Newbury.** (Sibley J. of Engineering, Cornell Univ., May, 1918. El. World, 71. p. 1378, June 29, 1918.)—The reason for limiting the voltage for which alternators are built is that after about 20,000 volts, the weight of the generator increases rapidly and the cost soon becomes greater than the combined cost of an equivalent lower voltage generator and transformer. Furthermore, in the absence of a transformer, the generator windings are exposed to the direct action of surges originating in the line. It is very difficult to protect generator windings against such surges by sufficiently good insulation on the conductors unless each coil has only a single turn, which would necessitate a prohibitive number of slots for the very high voltages under consideration. The highest standard generator voltage in America at the present time is 13,200 volts. The failures of extra-high-voltage generators are due to the chemical effects produced by the corona discharge, and to the large dielectric loss that occurs under the combined influence of high voltage and high temperature. Synchronous motors and generators are better adapted for the higher voltages than induction motors. A. J. M.

646. *Maximum Rating of Direct-current Machines.* **F. T. Hague.** (Elect. J., 15. pp. 42–48, Feb., 1918.)—The article reviews generally the factors that determine the max. rating of d.c. machines for given speeds.

The limitation to the output in low-speed machines is invariably set by considerations of heating, while in high-speed machines the limit is fixed by the commutation. For machines designed for abnormal duty cycles both these factors are of importance. The factors governing the rating, and which form the subject of the discussion, include the type of armature winding, construction of the commutator, number of poles, spacing of the brush arms, voltage per bar of the commutator, max. current of the machine, brush dimensions, division of current between the brushes, and quality of the brushes.

It is shown that the product of the kw. rating and speed in revs. per min. is a constant, on the basis of comparative commutation, for machines for any given voltage or class of service. This relationship is plotted in a series of

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curves, giving the suitable speed in revs. per min. for various outputs in kw. for different voltages. These curves are a series of hyperbolæ with the equation kw. × r.p.m. = constant, the constant having values between 600,000 and 1,150,000 according to the voltage of the machine. A. J. M.

647. *Efficiency of Machines with Aluminium Windings.* **G. Schönwald.** (Elektrot. u. Maschinenbau, 36. pp. 288–289, May 26, 1918.)—The question is considered whether aluminium is likely to be used as a material for the windings of electric machinery after the war, and calculations are made recording the changes in the dimensions of the machinery that would be necessary to obtain efficiencies as high as are obtained with machines having copper windings. Hitherto the requirements of the war have made it necessary to use existing frames and to replace the copper with Al in such a way as to obtain the greatest output with the smallest amount of material. This method is considered at length by R. Richter in his book entitled "Electric Machines with Windings of Aluminium, Zinc, and Iron."

It is now shown that machines of equal efficiency may be built with windings partly of copper and partly of Al. For instance, a d.c. machine with its armature winding of copper and its field windings of Al. In this way about ¾ to ⅘ of the copper may be replaced by Al. The Al windings contemplated are not the uninsulated ones that were already used before the war, but windings insulated in the same way as copper windings usually are.

If two similar machines have windings of the same section the Joulean losses of the Al machine would be 70 % greater than in the copper machine, and if these losses were in the copper machine 25 to 50 % of the total losses, the total losses in the Al machine of equal size and capacity would be increased by 17·5 to 35 %, and the efficiency would be lowered from 80 % to 76·5 to 73 %, or from 90 % to 88·5 to 86·5 %. According to Vidmar [Abs. 792 (1917)] these losses can only be reduced by increasing the section of the Al, which would necessitate increasing the size of the iron frame. In order to get equal output with the same losses the section of the Al would have to be 70 % greater than that of the copper. This necessitates increasing the diam. of the bore of the yoke of the machine and lengthening the poles. A calculation made on the basis of the 70 % increase of section shows that the bore would have to be increased from 14 to 16 % to obtain a machine technically equivalent to the copper machine. The question whether this machine would be able to compete commercially is difficult to decide at present, but on the assumption that the cost of the copper windings on the main and commutating poles amounts to ½ or ¾ of the price of the cast-iron yoke and pole cores, the price of the Al windings should not exceed that of the copper windings for equal weights by an amount exceeding 30 to 45 % in order that the original copper machine and the modified Al machine should cost the same amount.

It appears that there is some prospect of machines with Al windings being able to compete with machines with copper windings after the war. A. J. M.

648. *Commutation Voltage of Single-phase Motors.* **R. Moser.** (Elektrot. u. Maschinenbau, 36. pp. 173–176, April 14, and pp. 189–191, April 21, 1918.)—The calculation of the transformer and rotation voltages induced in the coils under commutation of single-phase motors is rather complicated even for the case of the motor with one single pair of brushes, even if the field is assumed to have the simple form of a trapezium, *i.e.* if the influence of the

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slotting of the armature and the effect of saturation are neglected. The calculations are still more complicated in machines like the Déri motor with double brushes.

It is now shown that both the above-mentioned induced voltages for the motor with double brushes may be easily deduced from formulæ for the case of the motor with a single pair of brushes. As these formulæ are not easily found in text-books, they are given in the article and from them expressions are deduced that apply to the Déri repulsion motor. It is furthermore shown that the Thomson and Déri motors approximate, in their electrical properties, to the case of an ideal motor with fields distributed according to the sine law and with a fixed distance between the short-circuited brushes. The connection between the voltages between the short-circuited brushes and the voltages (supposed known) between the brushes situated at the ends of diameters is shown to be given by the statement that the voltage between the short-circuited brushes is equal to half the sum of the voltages between the brushes taken in pairs across diameters. On this basis the transformer and rotation voltages of the Thomson motor are tabulated for various brush positions and for various ratios between the wound portion of the circumference of the stator to its whole circumference. The calculations are then extended to the case of the Déri motor, for which similar tables are drawn up. Finally a table is given comparing the case of the Déri motor with two-thirds of its circumference wound, and the motor with its field distributed according to a sine law. It is seen from the figures that the characteristics of the Déri motor may be calculated with great approximation by applying the formulæ of the motor with a single pair of brushes and with its field distributed according to the sine law. A. J. M.

649. *Characteristics of Current-transformers on Open Circuit.* **W. R. Woodward.** (Elect. J. 15. pp. 48–50, Feb., 1918.)—If the secondary circuit of a current transformer becomes open-circuited, the voltage wave produced becomes very peaky and the winding may be endangered. This distortion of the wave-shape is due to saturation and hysteresis, and the wave-shapes resulting from this assumption are shown to be in accordance with oscillograms that are reproduced.

Methods of measuring the max. value of the voltage peak are indicated. It is argued that this voltage is a function of the kv.a. rating of the circuit into which the current-transformer is connected, and a curve connecting these quantities is obtained from actual test results. A. J. M.

650. *Surges in Transformer Windings.* **K. W. Wagner.** (Archiv f. Elektrot. 6. pp. 301–326, 1918. Comm. from the Physikal.-Techn. Reichsanstalt.)—In calculating the rise of voltage caused by surges in transformer windings it was originally assumed that the winding may be considered as being a long conductor. This conception is simple, but does not suffice for calculating the stresses in the winding, because the surges in a winding spread out in quite a different manner from the surges in a long conductor, owing to the mutual action of the turns on one another. In previous articles the author has considered the coil as being made up of a series of reactances with capacities in parallel with each, and capacities to earth situated at the ends of each reactance, the mutual inductance between the adjacent sections being neglected. The mutual inductance was allowed for by O. Böhm [Abs. 718 (1917)].

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The author now points out certain mathematical errors in the paper in question, which he corrects. A special section is included concerning the calculation of resonance frequencies. A number of new formulæ are derived by which the production of surges in coils can be calculated more exactly than by previous methods. A. J. M.

651. *Behaviour of Three-phase Transformers on Unbalanced Load.* **R. Bauch.** (Elekt. Zeits. 39. pp. 245–248, June 20, and pp. 256–258, June 27, 1918.)—The article discusses the behaviour of core type 3-phase transformers in star-star connection in the event of load being put on to one phase, or one limb. Such loads are liable to occur in 3-phase 4-wire systems, or if one coil of a transformer becomes short-circuited by a surge, or if one line becomes earthed and the star point is normally earthed. The occurrence of such loading is shown to produce a leakage field that is not present in ordinary working, with consequential shifting of the neutral point of the transformer. Vector diagrams are given for a number of different connections including ordinary star connection and zigzag star connection on the primary or secondary, or on both the primary and secondary windings of the transformer. Considerable stress is laid on the difference in effect of single-phase load and single-coil load, and it is shown that if such loading occurs on the secondary, the primary currents are distributed very differently in the two cases. The effect of single-coil loading of star-star transformers is shown to be such that the load in the defective coil increases the voltages of the two sound coils to different extents; one of these decreases to a minimum of 83 % and then increases to a maximum of $\sqrt{3}$ times the phase voltage, as the loading is increased; the other one rises slowly to 1·82 times this voltage and then decreases to $\sqrt{3}$ times that value. The variations of the currents in the different windings are also followed up. A. J. M.

652. *Magnetisation of Three-phase Transformers.* **A. Mandl.** (Elektrot. u. Maschinenbau, 36. pp. 185–189, April 21, and pp. 197–201, April 28, 1918.)—The magnetisation of the 3-phase transformer with saturated limbs is investigated, with particular reference to the distortion of the wave-shapes of the magnetising currents in the three limbs by the hysteresis in the iron. The main subject that is discussed is the mode in which a transformer in star-connection, without neutral conductor, can be magnetised by a voltage strictly following the sine law.

At first the case of the symmetrical transformer is discussed, the field in each limb being divided up into portions that are linked with the adjacent limbs and portions that are closed through the air, forming magnetic shunts to the iron circuit. It is shown that the oscillations of the neutral point are exclusively produced by the sum of the air fluxes in the three limbs, and that these three fluxes are equal in magnitude, are in phase with one another and contain as components only the 3rd, 9th, 15th, etc., harmonics. If the magnetic reluctance in the circuit of the air fluxes is very great the induction in the cores may, to a first approximation, be taken to follow the sine law.

Tests were made with three transformers, each of which had three cores, placed together with one set of cores as near as possible to form a common magnetic return, and the cores on the extreme outside situated at the corners of an equilateral triangle. Only the windings on the outside cores were used, the remaining cores being merely employed as magnetic return

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circuits. Oscillograms are given of the circulating voltage in the low-tension windings of the three outside cores without neutral connection on the primary. The 3rd harmonic of the field reaches considerable dimensions in this case. In another test the primaries of the transformers were connected in star with neutral connection, and strong 3rd harmonics appear in the magnetising currents. The voltage between the star points of the transformer and generator show 3rd, 9th, and 15th harmonics. Further measurements were taken of the wave-shapes of the phase voltages of the generator and of the transformer, and oscillation of the star point of the transformer is shown to deform the phase voltage considerably.

The measurements and calculations are then extended to the case of the unsymmetrical 3-phase transformer, having one long and two short magnetic paths. The magnetising currents in the different phases exhibit very different shapes even when the iron is not highly saturated. An equalising current of triple frequency enters at the two outside limbs and leaves the transformer through the middle limb. The production of the triple-frequency air fluxes is explained by an analogy of three water pipes. These fields are shown to produce auxiliary losses in the transformer case, and at the same time a decrease of the losses in the cores by the depression that is caused in the max. values of the flux in the cores. The oscillation of the star point produces an exchange of energy from the iron of the three cores into the air, and this superposed oscillation causes a distortion of the no-load current of the fundamental frequency. The energy component of this superposed no-load current covers the losses in all three cores. A. J. M.

653. *Heating of Machines and Transformers.* **J. Fischer-Hinnen.** (Elektrot. u. Maschinenbau, 36. pp. 205–210, May 5, and pp. 217–222, May 12, 1918.)—At the present moment it is no longer the commutation but the heating that appears to give the greatest difficulty, and the object of the article is to collect the information available on this point and to supplement it where necessary.

The reduction of heating by ventilation is effective, but demands expensive installations of blowers, filters, etc., without which the insides of the machines become contaminated with dust or with a mixture of dust and oil, which is most destructive. On this account a machine giving a certain temperature-rise with the least artificial ventilation is the preferable one.

There are also differences of opinion as to the max. permissible temperature-rise, although there is little doubt that the values that are fixed at present could be exceeded in many cases—for instance, the 8750-kw. machines at the Niagara Power Station have been operating for years at temperatures varying between 120° and 280° C. according to the load, without any difficulty arising.

The author goes into details of the methods of calculating the temperature-rise on continuous load allowing for the radiation, convection and the chimney action in ventilating ducts, and discusses what should really be regarded as the radiating surface. Regarding the chimney action, tests are described on resistances enclosed in tubes, and a formula is found connecting the reduction of temperature caused by the chimney action of the ascending air. Regarding the cooling surface, it is pointed out that it is not of great importance to discuss what parts of the surface should be regarded as radiating, as the temperature-rise can be correctly arrived at using any method of estimating the radiating surface, provided suitable constants are used. A table is given showing the radiating constants of various types of transformers, motors, field

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coils, commutators, generator windings, resistance coils, etc., for definite assumptions regarding the effective radiating surface. A discussion then follows on the calculation of the necessary volumes of air, oil, or combinations of these two materials, required for artificial cooling. The formulæ obtained are applied to particular cases and the results compared with the values actually obtained on test. In conclusion the case of intermittent loading is considered in a similar manner.

The article is a comprehensive survey of the methods of calculating temperature-rises and should be of considerable use to designing engineers.

A. J. M.

654. *Starting of Rotary Converters.* **F. D. Newbury** and **M. W. Smith.** (Elect. J. 15. p. 24, Jan., 1918.)—When there are no switches between the collector rings of a converter and its transformer secondaries, the latter act as shunts to the armature and divert a large fraction of the starting current. This effect is greatest when the armature stops in such position that the d.c. brushes and the a.c. collector-ring taps are connected to the same coils. The change from maximum to minimum shunting effect occurs within a very small part of a revolution ($\frac{1}{8}$ rev. in the case of a 14-pole converter); hence barring the armature by hand for the space of two commutator bars may double the starting torque. In any case the torque developed when starting from the d.c. end is necessarily less when the transformer secondaries are connected permanently, than when the a.c. circuit is open. The extent to which the starting torque is reduced by the shunting effect depends upon the relative resistance of armature and transformer. The resistance of a converter armature may be 5 times that of a single secondary winding; and it is estimated that, in a typical case, the starting torque varies from 16·7 % of the torque which would be developed with the secondaries disconnected, to 58·8 % of the latter torque an eighth of a revolution later. This is the case in a 2-phase converter. In a 6-phase, diametrically connected converter there are three secondaries instead of two; hence the reduction in torque is greater. On the other hand the effect is less pronounced in a 3-phase or delta-connected 6-phase converter, because the armature is never completely paralleled by a transformer secondary.

Directly the armature begins to rotate, alternating current flows in the armature and transformer secondaries and the demagnetising effect on the converter field reduces the starting torque still further. The net result is that the d.c. starting current is several times greater than it would be if at least one switch were provided in each transformer secondary and these switches were opened before starting. The synchronising equipment should be on the low-voltage side of the transformers. The shunt field should be connected on the line side of the starting resistance so that full line voltage is applied to the field on the first notch of the starter. If this be not done the field voltage will be reduced by pressure drop in the starting resistance and it is probable that the machine will not start.

R. E. N.

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ELECTRICAL DISTRIBUTION.

655. *Resistance and Reactance of Iron Transmission Lines.* **A. Press.** (Electrician, 81. pp. 275–277, July 26, 1918.)—A mathematical theory is given that is applicable to circuits of variable permeability. The differential equations connecting voltage and current are first obtained, this leads to the solution for the case of a line of copper wire; finally the simultaneous effect of hysteresis and eddy currents on the resistance and reactance of iron wires is considered. The method introduces a mathematical operator that has the effect of changing $\sin pt$ into $\sin mpt$, and the permeability μ is generalised so as to be a differential operator defining the hysteresis loop. A. J. M.

656. *Economic Design of High-tension Transmission Lines.* **G. Horstmann.** (Elekt. Zeits. 39. pp. 193–196, May 16, 1918.)—It is shown that a number of causes tend to fix the voltages used in h.t. transmission lines, and that economic considerations are assuming a greater importance in their design than questions of voltage drop. The operating costs of lines are analysed and a distinction drawn between the most economical section for a given load and the most economical load for a given section. The latter condition is carefully examined with reference to the 100,000-volt lines of the Murg transmission system. Voltage regulators enable the lines to be calculated according to economic considerations alone, and this enables higher current densities to be used than if the voltage drop were the important factor. As the size of transmission systems increases, the attendant difficulties increase to a greater extent, thus tending to set limits to the size of stations and the voltage of transmission. It appears that the upper limit for distribution is 20,000 volts and for transmission 110,000 volts. The cost of three transmission lines and particulars of installation, insulators, masts, copper, etc., are set out in a number of tables. These lines are situated between Mannheim and Karlsruhe, Karlsruhe and Muggensturm, and Rotenfels and Forbach and the costs per km. are worked out for each in the form $a + bs$, where s is the section of the conductor.

The cost of a transmission line is made up of the costs of corona and insulation losses and copper losses and interest on the capital sunk. If those costs are plotted as functions of the current for various sections, a series of curves are obtained which show that there is a certain section for each value of the current that gives the smallest total cost. The calculations show that although the most economical section is obtained with a constant current density for all loads, the most economical current density varies with the section of the wire, increasing with decreasing section. A. J. M.

657. *Aerial Cable Construction for Electric Power Transmission.* **E. B. Meyer.** (Am. I. E. E., Proc. 37. pp. 561–570, June, 1918.)—The demands on supply stations having increased enormously from their pre-war values, it has become necessary to solve numerous operating problems in connection with the transmission system and to devise special methods of construction. The Public Service Electric Co. has adopted the method of

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meeting war-time demands by furnishing the customer with primary service by means of aerial cable run on poles and supported by a messenger wire. Bare wires were impracticable in some cases since the line had to cross freight yards and bridges, and it was impossible owing to marshy ground to run a duct line without foundation piling. Ordinary lead-covered cable was used but was found undesirable, and a special construction was developed whereby a covering of reinforced rubber was substituted for the lead sheath, the insulation remaining impregnated paper as before. This makes the cable lighter in weight, and when protected from mechanical injury it withstands weather conditions as well as if lead-covered. A full description of the construction of such a cable and also of the methods of suspending reinforced rubber and lead-covered cables is given; the company find that aerial construction is suitable for operation at 15,000 and 26,000 volts, and recommend its use wherever open-wire construction is undesirable and the time and cost of underground construction is prohibitive. It is unnecessary to use lightning arresters, as the messenger wire is permanently earthed; and in practice over a number of years no trouble has arisen from this source. The cost of an aerial cable line is about mid-way between underground and bare-wire construction. V. C.

658. *Standardisation of Three-phase Voltages.* **R. Rüdenberg.** (Elekt. Zeits. 39. pp. 233–235, June 13, 1918.)—It has recently been advocated by G. Stern [Abs. 617 (1917)] and others that three-phase voltages should be standardised to assist manufacture and the interchangeability of apparatus on different supply systems. The importance of carrying this out rapidly arises from the fact that the greater portion of the 3-phase networks of Germany are still to be built. In selecting the steps in a standard series of voltages it has been agreed that steps in the ratios 1·5 : 1 to 2 : 1 are suitable. There are advantages in choosing the ratio $\sqrt{3} : 1 (= 1{\cdot}732)$, as this enables the same windings to be used on two voltages by using star and mesh connections. An approximation to this ratio that gives similar steps of voltage in the various ranges in the decimal system of counting is $\sqrt[7]{10} : 1 (= 1{\cdot}778)$, which leads to steps such as 10, 18, 32, 56, 100 in each range of the decimal system. A diagram shows that the proposed standard voltages fall sufficiently near to existing voltages in installations between 500 and 32,000 volts. It is pointed out that most of the voltages in actual use can be brought into conformity with the proposed standard series by relatively simple means. Scales are drawn in juxtaposition showing the existing voltages in use, the proposed standard system and the systems previously proposed by Stern, Spyri, and the Vienna Electrotechnical Association.

A. J. M.

659. *America's Energy Supply.* **C. P. Steinmetz.** (Am. I. E. E., Proc. 37. pp. 591–615, June, 1918.)—This is a general consideration of the problem of power production. The author states that the total potential hydraulic energy of the United States is about equal to the total utilised fuel energy. The modern synchronous station must be used for large hydraulic powers, but with smaller sources of water power the induction generator (*i.e.* an induction motor, driven above synchronism) should be used. This relegates the excitation, regulation, and control to the main synchronous station, and permits the collection of the power by electrical means from the smaller stations. The author then considers the characteristics of the induction

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generator and its mode of operation, and discusses methods of avoiding its dropping out of step. In some cases an excess-speed governor could be used to cut off the water at 5 or 10 % above synchronism. Attendants might be employed to close the water gates in case of the opening of the circuit-breakers. If the speed is kept within 10 % of synchronism, no dropping out of step can occur : this must be taken into account in design. Suppose, on the other hand, that we generate steam at high pressure, and interpose, between the steam boiler and the heating system, some simple form of high-pressure steam turbine, directly connected to an induction generator, we can then tie the latter into the general electric distribution system. Whenever the heating system is in operation, electric power is generated as a by-product, mainly in winter, and largely during the day and especially the evening.

The present methods of burning coal are considered to be very wasteful.

W. H. S.

660. *Prevention of Line Disturbances by Suppression of Arcing Earths.* **W. Petersen.** (Elektrot. u. Maschinenbau, 36. pp. 297–308, June 30, 1918. Paper read before the Elektrot. Verein, Vienna.)—One of the main dangers to overhead conducting systems lies in the maintenance of arcs to earth initiated through atmospheric causes and by the action of birds. Trouble is only to be expected above certain current strengths, and on this account it is only the larger networks that are likely to be endangered. Furthermore, wood masts afford a greater measure of security than iron masts.

The production of arcing earths is caused by the piling up of unidirectional charges that are left on the conductors when the arc ceases temporarily. The process of the building up of such charges is examined, and it is shown that in a.c. networks twice the line voltage may be reached in a defective conductor through the superposition of the phase voltage and the above-mentioned static electric charge. This causes the arc to be restarted, and a succession of such restartings of the arc may cause the voltage to rise to four times the original value. As the capacity of the circuit available when the arc breaks is only half as great as that of the circuit presented to the restarted arc, the frequency during the quenching of the arc is generally twice as great as that during the ignition of the arc. Theoretical wave-shapes are drawn and compared with actual oscillograms. Tables are given showing the voltages to be expected in single-phase and 3-phase networks for different values of the capacities of the conductors between one another and to earth.

The second portion of the article is concerned with methods of preventing the formation of excess voltages, and it is concluded that a very useful precaution is to earth the neutral point through a resistance of such a magnitude that the steady charge is reduced in half a period to such an extent that the sum of the phase voltage and the voltage due to the steady charge does not greatly exceed the normal phase voltage. It is remarkable to note how completely the arc collapses on the introduction of such a resistance and how the violent and noisy arc to earth degenerates into a silently burning arc that goes out very quickly. A similar result can be achieved with horn dischargers associated with suitable resistances, but this method is inferior to the former, as the protective device only comes into operation after the high voltage has been generated.

Earthing through reactive coils is very effective. In contrast with the

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resistance method, several periods elapse before the voltage reaches its normal value, and after the arc is quenched the voltage rises so slowly that the best conditions are presented for the extinction of the arc, because the ionising of the air vanishes before the voltage rises to such values as to maintain an arc.

These theoretical conclusions are borne out by tests made of three interconnected 10-kilovolt networks fed by four separate generating stations. Earths were produced by damped string, but arcing earths were not produced when the system was suitably protected by reactive coils to earth. When using such coils it was found that exact adjustment of the constants of the coil is unimportant, and that good protection is afforded by coils varying somewhat in their dimensions. A. J. M.

661. *Method of Symmetrical Coordinates applied to the Solution of Polyphase Networks.* **C. L. Fortescue.** (Am. I. E. E., Proc. 37. pp. 629–716, June, 1918.)—Unsymmetrical systems of co-planar vectors may be represented by symmetrical systems of the same number of vectors, the number of symmetrical systems required to define the given system being equal to its degrees of freedom. It is shown how unsymmetrical groups of numbers may be reduced to symmetrical groups. These numbers may represent rotating systems of operators. By the means indicated, unbalanced polyphase systems may, for the purpose of calculation, be reduced to two or more balanced systems. The method is applied to the case of symmetrically wound polyphase machines operating on unsymmetrical circuits, such as induction motors on unbalanced supply circuits, 3-phase generators on unbalanced loads (single-phase generators being considered as a special case under this heading). Single-phase induction motors, synchronous motor-generators, and phase-converters are also discussed. A. J. M.

662. *Power Factor and Energy Tariffs.* **A. Iliovici.** (Rev. Gén. d'El. 4. pp. 102–104, July 27, 1918.)—The author considers that the consumer should pay for the energy indicated by the formula $W = \Sigma[VI \cos\phi + AVI \sin\phi]\Delta t$, where A is an empirical coefficient the value of which should be comprised between 1/3 and 1/4.

General indications for transforming ordinary meters into meters measuring the energy as indicated above are given, as well as tables and curves showing the differences between the values given by the above formula and those given by other known formulæ. E. B.

663. *Increasing Equipment Rating.* **H. C. Albrecht.** (El. World, 71. pp. 1260 and 1262, June 15, 1918. Extracts from paper read before the Nat. Electric Light Assoc., Atlantic City, June, 1918.)—The author quotes various methods employed to increase the output of existing equipment. In the North-West the output of two 10,000-kw. hydroelectric generators was increased to 14,000 kw. (continuous rating) at a cost of $1000 by providing forced ventilation. The turbines were initially rated at 21,000 h.p. Later it was possible to obtain 16,000 h.p. continuously from each machine by re-insulating with material which could stand higher temperatures. In other cases the Δ–Δ connections have been changed to Y–Δ to permit larger loads to be carried. In the Stanislaus hydroelectric station some 8500-kw. units were fitted to carry 10,000 kw. by forcing air from the tail-race through the generator windings. W. N. Y. K.

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664. *Electrical Interconnection in Massachusetts.* (El. World, 72. pp. 257–259, Aug. 10, and pp. 299–301, Aug. 17, 1918.)—This article outlines a scheme for the interconnection of a number of local electric light companies in the district south of Boston, and for the running of a duplicate line from Boston to Fall River. W. H. S.

665. *Electricity for Nitrate Plants.* (El. World, 71. pp. 1358–1359, June 29, 1918.)—Near Sheffield, Alabama, the U.S. Government is erecting two nitrate plants, one using the synthetic process and the other the cyanamide process. One plant uses water power at Muscle Shoals on the Tennessee River, and the other is supplied from the Alabama Power Co., which has a hydro-electric station on the Coosa River. Other plants of a similar nature are in contemplation in Ohio, one at Elizabethtown and the other at Toledo. The steam turbines required for nitrate and munition plants have been commandeered from the central stations of the country, the Government undertaking to substitute other units. W. H. S.

666. *Power-limiting Devices.* (El. Rly. J. 52. p. 19, July 6, 1918.)—Under the contract by which the Chicago, Milwaukee, and St. Paul Railway obtains power from an outside source, it becomes necessary for them to reduce the max. demand to the greatest extent that is possible. The power indicating and limiting system for securing this result consists of a 1200-volt circuit run from the first to the last substation and fed from a very small motor-generator in the load dispatcher's office. There are also automatic devices which cause the trolley voltage to be lowered over a certain district when the critical value of the load is reached. This decreases the speed of the trains temporarily without ill-effects. The max. reduction in load is found to be about 80 % : the apparatus is so arranged as to reduce the voltage of the most heavily loaded substation first, and to throw the load partially on the other substations. Indicating wattmeters are mounted on the switch-board in the load dispatcher's office, which show at any instant the total kilowatts supplied by the power company. W. H. S.

667. *Swiss Report on Corrosion by the Earth Currents of Electric Railways.* (Schweiz. Elektrot. Verein, Bull. 9. pp. 135–152, July, 1918. First Report of the Joint Committee of the Swiss Gas and Water Inst., the Inst. of Swiss Secondary Railways, and the Swiss Electrot. Inst.)—The corrosion of gas and water pipes and of the sheaths of cables has given cause for considerable complaint in Switzerland, particularly in two towns, and on this account the above-mentioned joint committee was formed. Trouble on a large scale has been experienced only in the larger towns with concentrated d.c. tramway services.

The committee has drawn up a programme of work consisting of five different parts : (1) General report on the question of corrosion and methods of protection, (2) Collection and utilisation of the results of experience, (3) Results of measurements on typical tramway systems, (4) Regulations for the construction and maintenance of installations, (5) Organisation of a permanent controlling body.

The present report refers to the first section only. It is divided into two parts : the first is theoretical and discusses the production of corroding current and their laws of flow ; the second part reports on the magnitude and nature of corrosive effects and their causes.

The corrosion takes place at the point where the current enters the

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earth and does not depend on the total current that enters the earth, but on the current density at the anode. The danger to a pipe expressed as a depth of corrosion is given by $k.(a/\gamma).T.p_{max.}/(\Delta r_e)$, in which k is a constant depending on the loading of the tramway section, a the electrochemical equivalent of the metal subjected to corrosion, γ the specific weight of the metal, T the time for a car to traverse the total length of the section, $p_{max.}$ the max. permissible voltage drop in the rail, Δ the breadth of the surface of the pipe from which the current issues, r_e the total resistance between the pipe and rails per unit length of track, including the transition resistance between the pipe and the earth, the rail resistance and the back e.m.f. of the cell formed by the pipe and the rails as electrodes. The regions at which the current leaves the pipe or the rail depend on the nature of the tramway service, and for the different types of services discussed it is shown that there are certain points that are neutral, no current passing from one system to the other, and that the direction of the earth current reverses at such neutral points. The value of k, as regards corrosion of the pipe, is worked out for a number of different types of loading of the tramway section, and is found to be 1/8 for a simple outward and return service with one car, and 2/8 for a uniformly loaded section with many cars, and to be 1/6 and 1/8 for corresponding cases, as regards corrosion of the rails.

The material of which the pipes are made has an important effect on the corrosion, as is shown by a list including a number of different metals, from which the thickness of corrosion is calculated for a flow of current for a year at a density of 0·001 amp./dm.^{2}. In this list copper and lead show the greatest corrosion thickness of 0·282 and 0·295 mm. respectively, whereas other metals approximate to a thickness of corrosion of 0·110 mm. The corrosion must be expected to decrease with an increase in the diam. of the pipe, as the value of Δ increases with larger pipes. It should also be noted that Δ depends on the distance between the rails and the pipe.

The earth resistance consists mainly of the resistance at the points of leaving the pipe and rails, and should be kept high by using a well-insulating dry bed for the rails. In the case of the pipes the resistance may be increased by providing an insulating sheath. The conductivity of the earth depends on the distance between the rails and pipes, and above certain distances no danger is to be feared from corrosion. In the first part of the report the resistance of the material of the pipe is considered to be negligible in comparison with the resistance of the earth. It is then pointed out that an increase in the resistance of the pipe decreases the amount of corrosion by the alteration effected in the distribution of the potential along the pipe.

In order to keep the voltage drop as low as possible in the rails, and thus decrease the danger of corrosion, very careful connections should be made between the sections of the rails, and as a further precaution the track may be subdivided at several feed-points. A table showing how subdivision affects the voltage drop with different numbers of feed-points and several types of services proves that, although the provision of a second feed-point effects considerable reduction in the voltage drop, a further increase in the number only decreases the voltage to a much smaller extent.

The rails are usually connected to the negative pole, so that the area of corrosion of the pipes lies in the neighbourhood of the feed-points. A reversal of the polarity transfers the danger area to the portion of the pipe

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into which the current previously entered. An examination of the distribution of the area of corrosion in the two cases shows that for sections that are not closed loops the total amount of corrosion is smaller if the rails are positive than if they are negative. This must not, however, be taken as an argument for making the rails positive for every type of service.

If a section of rail with only small traffic, or no traffic at all, is connected to the end of a section, the amount of corrosion of the pipe is thereby lessened if the lightly loaded section is connected to the end of the loaded section remote from the feeder, and the rails are positive. The corrosion is also lessened if the lightly loaded section is connected to the feeder end of the loaded section, and the rails are negative. In any case the total current in the pipe is increased by the addition of the extra section. These considerations lead to the provision of earth plates at the negative feed-points of the rails, in order to reduce the current density of the currents leaving the pipe. The effect of the earth plates is similar to that of the added lightly loaded section of track, inasmuch as both arrangements are equivalent to an increase of the area of the electrode.

Further investigation shows that any departure from equal voltages at the different rail feed-points causes an increase in the danger of corrosive action, if the rails are positive. If the rail feed-points are negative, departure from equal voltages at the various rail points shifts the area of danger from sections of higher potential to those of lower potential.

If pipes are situated so as to cross the direction of the rails, corrosion is often found at points near to the crossing. An example is given of a pipe crossing a double track, and it is shown that the corrosive action depends on the voltage difference between the two tracks at the points where the pipe crosses, which varies with the service of trains on the two tracks and is therefore very difficult to follow by calculation. If both tracks are equally loaded and fed from both ends the crossings will be at about the same potential and the danger of corrosion will be small. In order to avoid corrosive effects, care should be taken that the potentials of the rails at the points of crossing the pipe should be as nearly equal as possible. Danger is also present when pipes are branched off from a main pipe lying parallel to a track, if such branch pipes cross another track. Very considerable earth currents may be produced under such conditions, and in order to limit the corrosive effects, the earth currents in the main pipe should be reduced as far as possible at places where the branch pipes are taken off. Protective devices such as earth plates connected to pipes and rails have the object of confining the earth currents to a single neighbourhood and are therefore not suitable for complicated branched networks of pipes. In fact, they may often increase the danger to which the pipes are exposed. [The report will be continued in a later issue.] A. J. M.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

668. *Risks of Light-weight Traction Motors.* (Am. I. E. E., Proc. 37. pp. 985–989, Aug., 1918.)—This is the report of a committee under the chairmanship of N. W. Storer.

Experience in the U.S.A. last winter showed the superiority of electric over steam traction in respect of (1) reliability in severe weather, and (2)

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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great traffic capacity. Other advantages of electric traction are fuel economy, high-class service, and safer operation on severe gradients and in tunnels. The Chicago, Milwaukee and St. Paul Railroad is continuing its 3000-volt d.c. electrification and should have 650 miles of electrified main line in service within the next 6 months. Though electric railways gave satisfactory service last winter, the electric tramways suffered many breakdowns, a number of which were due to light-weight motors being used without recognition of their limitations. Ten years ago the standard tramcar equipment was four 40-h.p. non-ventilated motors. There certainly was need to reduce the weight of this equipment, but the weight-cutting movement has now gone rather too far. The light-weight ventilated motor has come to stay, but it must be remembered that open ventilation introduces risk of snow entering the working parts; high armature speeds accelerate deterioration of armatures and wear of bearings; reduced weight means more or less increase in stresses in material; light weight involves low thermal capacity to absorb the heat of severe temporary loads. Precautions necessary to overcome these risks are: (1) Fit tight covers over motor openings in winter-time. (2) Build armature strongly enough to withstand its additional stresses; and make bearings large and well lubricated. (3) Use high-grade steel, but rather to secure higher factor than to cut weight to an absolute minimum.

With motors having ample thermal capacity, it was sufficient if the continuous rating equalled the integrated loads in service; but this is not the case with modern highly ventilated motors which have relatively a very high continuous rating compared with the 1-hr. rating, which is really the measure of the thermal capacity of the motor and its ability to withstand heavy intermittent loads. If a motor be required to develop 4 times its continuous rating for a few minutes, this amounts to 60 % above the 1-hr. rating of a non-ventilated motor, but 2½ or 3 times the 1-hr. rating of a highly ventilated motor. This may be allowed for by choosing a higher continuous rating for ventilated than for non-ventilated motors. If carried to extremes, the light-weight movement costs more in maintenance and breakdowns than it savesi n reduced transport costs. Apart from savings due to reduced weight there is room for great economies by improved methods of operation and further use of field control. There are good prospects for regenerative control, at any rate on overhead and subway systems. R. E. N.

669. *Electric Traction and Hydraulic Power in Italy.* (Elettrotecnica, 5. pp. 242–244, June 25, and pp. 270–277, July 15, 1918.)—The anonymous author of this article considers that the 3-phase system for electric railways has an unfavourable influence upon the national economy of Italy, as the peculiar frequency, separate apparatus, losses in the line, etc., influence detrimentally the cost of the energy both for railways and for private consumers, and are inconvenient for a rational and economic utilisation of the hydraulic forces. An example shows that if the 3-phase railway were replaced by a direct-current one, the cost of the installation would be diminished by 15 %, and the cost of the energy for traction by 52 %. The relatively high cost of production of 3-phase energy for traction leaves a very moderate profit for the energy seller, who, consequently, is obliged to charge more to the private consumer in order to balance matters: this constitutes an unfavourable condition for the general national economy.

The actual installations in Italy for the transport of electrical energy are

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of a random nature, the lines running parallel or crossing each other, but not being connected as would be desirable in order to help each other. The author would install 3-phase lines at 75,000 volts along the chief branches of railways, static substations conveniently placed being used for lowering the pressure to 12,500 volts, and synchronous rotary substations further converting to direct current at 3000 volts. In this manner the power factor could be high, the saving important and the problem of the unification of the frequencies for the existing installations could be solved through the d.c. transformation. The electric traction schemes could be conveniently operated with this last form of current.

The advantages of the d.c. traction system on railways over the 3-phase system are considered at length : these are both of a technical and an economic nature. The author calculates the cost for the entire electrification of the Italian railways, adopting one or the other of the two systems. The chief results are as follows :—

3-phase—Cost of installation, 732×10^6 lire—Cost of operation, 133×10^6 lire
Direct current— „ , 482×10^6 „ — „ „ , 87×10^6 „

The single-phase system of traction could perhaps compete with the d.c. system, both from the technical and economic sides, but the unfavourable influence of the former system upon the telegraph and telephone installations constitutes a heavy drawback. E. B.

ELECTRIC LAMPS AND LIGHTING.

670. *A New Arc for Electric Searchlights.* **V. Bellini.** (Elettrotecnica, 5. pp. 286–287, July 25, 1918.)—To avoid the flaming of the Beck and Sperry arcs, the author proposes to cool the positive carbon, instead of the arc, by an air-jet. Another important result is obtained in this way, namely, that the arc pressure is reduced to 50 volts, the voltage of the Beck and Sperry arcs being 70 volts. The new searchlight comprises three electric motors; one is used for slowly rotating the positive carbon, another for the centrifugal pump producing the air-jet, and a third one energises an aspirator for extracting the smoke produced by the combustion of the carbons. The air-jet discharges itself under positive carbon through a rectangular slit. As actually constructed, the apparatus absorbs 120 amps. The Italian military authorities have adopted this device for transforming the ordinary searchlights.

Special care is required in choosing the carbons. The copper sheath must not be thicker than 6/100 mm., as otherwise the drops of molten copper damage the mirror. The core of the positive carbon must not have too low a melting-point, and must be formed chiefly of cerium salts. E. B.

671. *Enclosed Arc with Low Voltage-drop.* (Wireless Age, 5. pp. 453–454, March, 1918.)—The arc here described, due to J. Clough, consists of a low-expansion glass envelope, such as a sodium-magnesium, boro-silicate glass, with a kathode of tungsten, tantalum or carbon, the anode being made up of metallic Ca, Mg, Ti, or other metal highly reactive chemically to gases other than the inert so-called rare or monatomic gases. The kathode is preferably provided with a tip having a greater diam. than the adjoining sections. With such an arrangement the drop in voltage across the arc may be as low as 4 or 5 volts, and the voltage required to start the arc is also low. A

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15-amp. arc, for example, may be formed with a potential as low as 14 volts, provided the temperature of the kathode is 2500° C. A. W.

672. *Methods of Directing and Concentrating Light.* **H. T. Harrison.** (Illum. Eng., London, 11. pp. 72–79 ; Disc., 79–91, March, 1918. Paper read before the Illum. Eng. Soc., Feb. 26, 1918. El. Rev. 82. pp. 222–223, March 8, 1918. Abstract.)—The c.p. derived from a source in any direction, with or without reflector, can be readily calculated if brightness and area of emissive surface are known. This is illustrated by the polar curve of an arc crater, with negative removed, brightness being taken at 85,000 candles per sq. in. In a recent high-c.p. searchlight, a brightness of 250,000–300,000 candles per sq. in. has been attained ; the luminous surface is, however, not plane but convex, owing to the contents of the crater boiling over. The polar curve of light distribution from a crater of this type is reproduced.

Results obtained with incandescent filaments in polished reflectors are also discussed, the multiplying power of mirrors embracing 90°, 180°, and 240° being given. With shallow parabolic reflectors, the apparent c.p. can be increased 800 times, with mirrors of 270° class as much as 2000 times, with a dispersion of 5°. The application of such units to indoor lighting is also discussed, the author contending that by illuminating only a confined central portion of a ceiling, a better result is attained than when the flux of light is directed over the whole ceiling and part of the walls, as is common in ordinary indirect lighting. In the *discussion*, this latter suggestion was considered by several speakers, and the desirability of standard types of lamps emphasised with a view to exact focusing of filaments. J. S. D.

673. *Lighting of Offices and Drafting Rooms.* **W. Harrison.** (El. Rev., Chicago, 72. pp. 864–867, May 25, 1918.)—Two conditions are of great importance in lighting offices—the size and shape of the rooms and the reflecting power of walls and ceiling. In an approximately cubical room 25 % of the light may reach the working plane ; if the horizontal dimensions of the room are five times the ceiling height, other conditions being similar, 50 % of the light supplied may reach the working plane. The following data are presented to show the effect of accumulation of dust on fittings and discolouration of ceiling with age :—

	Illumination (Candle-ft.).	Per Cent.
Original conditions	3·75	100
After cleaning reflectors.....	4·68	125
„ also installing new lamps.....	5·26	140
„ also repainting ceiling	6·75	181

Thus merely cleaning reflectors improves the illumination by 25 %, and refinishing ceiling with paint of lighter tint causes another 80 % improvement. In the subsequent portion of the article the author gives a table of coefficients of utilisation for various systems of lighting, and for light, dark, and medium surroundings, and discusses the best positions for direct and indirect units, appropriate data-charts being presented. A typical problem is worked out. An illumination of 6 candle-ft. is recommended for general office work. J. S. D.

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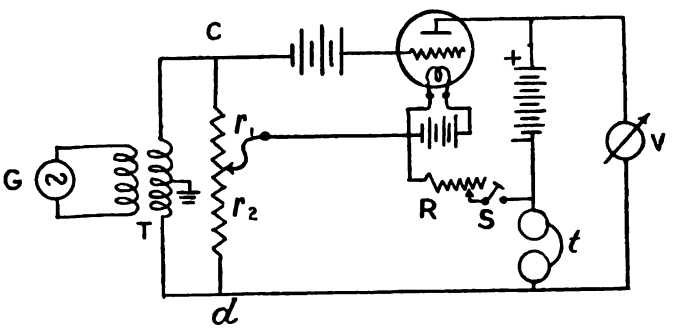
TELEGRAPHY AND TELEPHONY.

674. *The Wireless Telegraphy System of the French Government.* **J. B. Pomey.** (Rev. Gén. d'Él. 15. pp. 675–678, May 11, 1918.)—The system of wireless telegraphy of Bouthillon consists in charging a condenser by a constant e.m.f. The process consists in a rise in the charge on the condenser until a spark passes across the gap and discharges the condenser. This is again charged, and so on. The charging currents flowing at the moments of the breakdown of the gap tend to a limiting value, and when this is reached the condition of musical sparking is obtained. The equations of the system are worked out both for revolving spark dischargers and for stationary gaps, and the stability of the operation is investigated. A. J. M.

675. *Determination of the Characteristics of Three-electrode Vacuum Tubes.* **J. M. Miller.** (Inst. Radio Eng., Proc. 6. pp. 141–148, June, 1918.)—The paper describes a new method for determining the amplification constant and internal resistance of such tubes directly and rapidly. The method is based upon Vallauri's equation, $i_p = av_g + bv_p + c$, giving the relations between the grid voltage v_g, the plate voltage v_p, and the plate current i_p. In this equation a is the slope of the (plate-current)–(grid-voltage) characteristic and b is the slope of the (plate-current)–(plate-voltage) characteristic.



The experiments are directed to determining the quantities a/b and $1/b$ from which a and b are easily deduced. The first quantity is the same as k in Langmuir's formula, $i_p = A(v_p + kv_g)^{3/2}$ [see Abs. 614 (1915)], and is constant for a given tube, being known as the "amplification constant." The second quantity is the internal a.c. resistance of the tube in the plate circuit, and its value depends on the plate and grid voltages, and to some extent upon the filament temperature.

Assuming that the plate circuit is closed through a certain impedance and that an alternating e.m.f. e_g is impressed between the grid and filament, it is shown that the alternating current in the plate circuit will be the same as that which would flow in a simple a.c. circuit, in which the impressed e.m.f. is ke_g, and which contains a resistance $1/b$ in series with the inserted impedance. This theory enables the amplification constant and internal resistance of the tube to be determined directly and rapidly by using alternating current of audio-frequency by using a bridge connection as shown in the diagram, in which cd is a slide wire supplied through a step-down

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transformer T from a source of alternating current G; R is a dial resistance box going up to about 10,000 ohms, which may be connected into circuit by the switch S.

The amplification constant k is determined with the switch S open by adjusting the slider until the telephone t is silent, under which condition $k = r_2/r_1$.

The internal resistance is determined with the switch S closed, and the slider set at any point on cd, silence being obtained by varying R. Under these conditions the resistance of the tube is given by $(kr_1 - r_2)/R r_2$.

The method is illustrated by application to two types of tubes, for which curves for the amplification constant and internal resistance are drawn as functions of the plate voltage. A. J. M.

676. *Receiver for Damped and Undamped Oscillations.* (Wireless Age, 5. pp. 451–452, March, 1918.)—Describes a receiving circuit due to R. A. Weagant. The valve employed, of tubular form, has a cylindrical metallic envelope connected to one terminal of the tuning condenser of the secondary circuit. The anode is connected to the other condenser terminal and also through a resistance shunted by a variable condenser c_1 to the high-voltage battery. A second condenser c_2 is introduced across the high-voltage battery and the telephones. By means of this combination of capacity and shunt resistance the voltage of the anode battery may be adjusted to a value higher than would be possible without its use, and thus a considerable amplification is secured. By correct adjustment of the anode battery, the filament current, and condensers c_1 and c_2 the valve may be made to oscillate at an audio- or radio-frequency, and thus the arrangement may be employed as a receiver for undamped oscillations. The resistance in the anode circuit must be of the order of the normal resistance of the circuit between the filament and anode. A. W.

677. *Charging of a Condenser with Alternating Current.* **J. B. Pomey.** (Rev. Gén. d'El. 4. pp. 3–4, July 6, 1918.)—The conditions that exist during the charging of a condenser shunted by a spark-gap and fed from an a.c. supply are examined from a mathematical point of view. The relations between the constants of the circuit are obtained for the max. energy to come into play. In order that the sparks should pass in the same direction, the musical frequency must be half that of the supply. The value of the sparking voltage for the state of musical sparking is determined. It is probable that this corresponds to a very stable state. A. J. M.

678. *Amplifying Receiving System.* (Wireless Age, 5. pp. 628–630, May, 1918.)—If a coil of wire without shunt capacity is excited by a transient e.m.f., it will oscillate at a frequency determined by the inductance and the distributed capacity between the turns. If such a coil is earthed at one end, its period of oscillation will be decreased and a loop of potential will exist at its free end. An amplifying receiving system based to some extent on this phenomenon has been devised by E. E. Bucher. Three practical circuits are given. In the first of these the aerial inductance is coupled to a secondary inductance by means of a variable condenser. The secondary inductance is connected at one end to the grid of a valve, the anode circuit of which includes the telephones, which are shunted by a variable condenser. The secondary inductance is of such dimensions that the circuit from the grid through the inductance and coupling condenser, and thence through a

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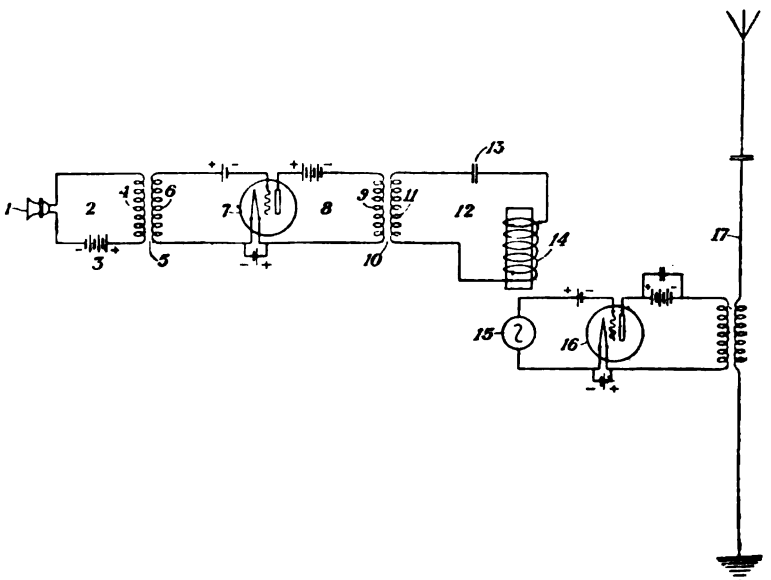
portion of the aerial inductance to earth, has the same natural frequency as the incoming oscillations. During the reception of signals a high e.m.f. exists at the free end of the secondary inductance, and hence this type of circuit impresses upon the grid a higher e.m.f. for a given group of oscillations than would be obtained from the usual secondary circuit. The second and third circuits described are slight modifications of the above. In the second, a variable condenser is shunted across the secondary inductance, and this results in sharper tuning. In the third arrangement the negative end of the filament of the valve is earthed, and while this does not affect the tuning, it permits of several receiving circuits of this type being connected to the same aerial, each tuned to a different frequency, and these different circuits do not mutually interfere. A. W.

679. *Wireless Telephony.* (Wireless Age, 5. pp. 281–282, Jan., 1918.)—J. R. Carson has recently designed a wireless telephone transmitter, the important feature of which is that the aerial radiates no energy until the microphone transmitter is spoken into. The circuits are shown in the accompanying diagram. The circuit 12 includes the field winding (14) of a high-frequency a.c. generator (15), to the armature of which is coupled a vacuum tube amplifier (16), whose output circuit is coupled to the aerial. Several amplifiers may be used in parallel at this point if desired. It is evident that there is no d.c. com-



ponent in the field winding (14) of the generator, and that alternating current flows in the field winding only when the transmitter (1) is spoken into. Hence the h.f. currents which set the aerial into oscillation are generated only when the transmitter is in use. By means of the condenser 13, circuit 12 may be tuned to offer a low impedance to the signalling frequency. The amplitude of the high-frequency wave radiated from the aerial is proportional to the low-frequency signal wave. In ordinary radiophone systems there is a continuous radiation of energy in the form of the unmodulated carrier wave, even

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when the transmitter is not spoken into. The transmission of this unmodulated wave constitutes a serious bar against the operation of duplex systems. With Carson's system energy radiation automatically ceases when the transmitter is not in use. A. W.

680. *Variable Condenser and Inductance.* (Wireless Age, 5. pp. 844–846, July, 1918.)—Describes in detail the construction of a variable condenser, designed by F. Lowenstein, such that equal increments of capacity are obtained for equal angular displacements of the set of movable plates. The fixed plates are semicircular as usual, while the movable plates are cut off at such different angles as to produce the desired logarithmic characteristic. The movable plates are thus sectors of circles, the angle of the sectors decreasing gradually from 180° to about 30°. The condenser is associated with a variable inductance element, also logarithmic in character, in such a manner that both inductance and capacity may be varied together in a reciprocal relation, or each may be varied independently. A. W.

681. *Preparation of the Kathode for Electron Discharge Apparatus.* (Wireless Age, 5. pp. 539–541, April, 1918.)—Describes in greater detail the method of preparing thoriated kathodes as used in Langmuir's rectifiers [Abs. 596 (1918).] Experiments have shown that the high electron emission obtained is probably due to a surface film of metallic thorium formed by the special heat-treatment. If a trace of oxygen is introduced into the discharge tube, the electron emission becomes very much lower than that of the unoxidised metal. When, subsequent to oxidation, a trace of hydrocarbon vapour is admitted, the electron emission suddenly rises as though reduction were taking place. A. W.

682. *Transpositions for Power and Telephone Circuits.* **H. S. Osborne.** (Am. I. E. E., Proc. 37. pp. 789–778, July, 1918.)—An account of the methods of applying the system of coordinated transpositions developed in connection with the investigations of the Joint Committee on Inductive Interference in California. The theoretical discussion of the mutual inductive effects is enormously simplified by the fact that for good operation the transfer of energy must be so small that the reaction of the induced current on the inducing circuit is negligible. The mutual inductance unbalance between all pairs of circuits on a 40-wire pole route is readily computed, but for the electrostatic effects it is much more practical to make actual measurements of the capacities between each wire and every other. A table giving these capacities for a 40-wire route is given. On long circuits the change in magnitude and phase of the current in the disturbing circuit and also of the induced currents has to be reckoned with. The e.m.f. induced in one km. cannot be perfectly balanced against that induced in another km., so that there is always a resultant "type unbalance" which must be kept below the desired limit. There is also an unbalance due to the fact that it is impossible to locate the transpositions at exactly the correct points and that there are small changes in separation which cannot be avoided. Serious complication is introduced by phantom circuits which must be transposed against their component and other physical circuits and against other phantom circuits as well as against outside disturbing circuits.

In designing a transposition scheme for a route use is made of a list of selected typical arrangements, particulars of which are given. The

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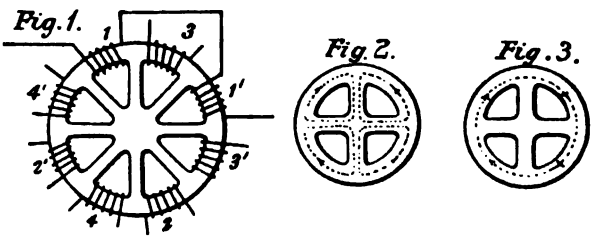
chief types of outside disturbing circuits are discussed; the case of 3-phase power circuits presents special difficulties and is dealt with in detail. The method followed in the design of a transposition scheme is to compute for each pair of circuits the length of unbalanced exposure which would give the limiting value of the induced current. This length is reduced by an allowance for irregularities. The remaining total type unbalance is converted to the permissible unbalance per transposition section. Schemes for routes exposed to outside sources of disturbance must provide flexibility for the arrangement of transpositions in the power circuits and balance against the effects of ground return circuits as well as freedom from cross-talk between the telephone circuits themselves. In addition, neutral points must be made to coincide with discontinuities in the parallel, the cost must be a minimum consistent with effectiveness and as few as possible transposition poles should be required. Two schemes selected as best meeting these requirements have been standardised as the "E" and the "L" sections, having 64 and 32 transposition poles per section respectively. Diagrams of these sections are given and their uses discussed. Four appendices deal with the theoretical calculation of (A) the induction between parallel wires, and (B) between two long parallel circuits; (C) the type unbalance in ordinary, and (D) in phantom circuits. [See also Abs. 946 (1916).] W. H. G.

683. *Loading Coil for Superimposed Circuits.* (Brit. Pat. 115,685 [of 1917]. Engineering, 106. p. 187, Aug. 16, 1918. Abstract.)—This is a single coil for loading simultaneously the phantom and side circuits, in which the windings are subdivided in order to avoid out-of-balance. The windings are arranged on an annular core which is traversed by a number of diametral limbs (Fig. 1).



Windings in alternate spaces belong to the same side circuit. The number of the diametral limbs may be 2, 4, 8, etc., and the number of windings therefore 4, 8, 16, etc. The flux produced by the currents in the side circuits follows the paths shown in Fig. 2 and that produced by the currents in the phantom circuit is annular, as shown in Fig. 3. The arrangement is due to G. E. Bairsto and H. H. Harrison. W. H. G.

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SCIENCE ABSTRACTS

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

OCTOBER 1918.

PRIME MOVERS.

STEAM PLANT.

684. *A New Theory of the Steam Turbine.* **H. M. Martin.** (Engineering, 106. pp. 1–3, July 5; 53–55, July 19; 161–162, Aug. 16; 189–191, Aug. 23; and pp. 245–246, Sept. 6, 1918. Third Report of the Committee on Gaseous Explosions.)—Experience in the application of theory to the design of the steam turbine has disclosed some remarkable anomalies—*e.g.* the well-established experimental result that under certain conditions the weight of steam discharged from a nozzle was actually greater than was physically possible according to the then-accepted theory, which assumed that the expansion of wet steam normally proceeds under conditions of thermal equilibrium. This hypothesis was proved false by Aitken in 1880, and later experiments of C. T. R. Wilson and Stodola caused it to be abandoned. Callendar has given an exhaustive study of the whole problem in his paper on the "Steady Flow of Steam through a Nozzle or Throttle" [Abs. 329 (1915)]. The present article gives apparently strong reasons for believing that another great outstanding anomaly in steam-turbine engineering is to be traced to the same error. Evidence of experience favours the view that steam in the "saturated field" of the Mollier diagram is never in thermal equilibrium until the condenser is reached. It has long been noted that the temperature of steam as indicated by a thermometer in a turbine exhaust pipe was sensibly below that corresponding to its pressure, *e.g.* Exhaust pressure, 0·671 in. Hg; Corresponding temperature, 67·2° F.; Observed temperature, 61·0° F. [Abs. 72 (1917).] The low readings are the more remarkable in that experiments have shown that a thermoscope immersed in a current of a permanent gas tends to give too high a reading owing to the adiabatic compression of the fluid against the obstacle. In the case of the turbine exhaust temperature the more the thermometer pocket is shielded from the rush of the steam, the nearer is the reading to the equilibrium value. Stodola's experiments on condensation are referred to in connection with under-cooling in a turbine exhaust pipe. The droplets were formed in jets of undercooled steam

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in about $\frac{1}{2000}$ of a second. C. T. R. Wilson in 1897 observed that additional condensation took place on new nuclei if the range of expansion was increased beyond that just necessary to produce condensation [Abs. 625 (1915)]. The time taken for the expansion in Wilson's experiments was estimated at something over $\frac{1}{150}$ sec., *i.e.* it was of the same order as the time taken for steam to pass completely through a modern turbine, and the inference is unavoidable that the steam is finally discharged in a greatly under-cooled and supersaturated condition. This does not agree with the results of Stodola's experiments. A detailed discussion endeavours to show that a certain interpretation of Wilson's results allows both superheat and vacuum corrections to be rationalised, while the contrary view involves wide discrepancies between theory and practice. The Callendar "Steam Tables" published in 1915 have been used in the investigations, and a steam chart based on Callendar's tables and formulæ is given to enable the processes to be followed more readily. Re-heat Factor Charts and many tables are also given. In conclusion, the principal points of the new theory are recapitulated. In actual turbine practice the expansion of wet steam never does occur in a condition of thermal equilibrium, as evidenced by the defect of temperature reading. That the true defect of temperature may amount to many degrees is to be inferred from Wilson's experiments on the expansion of supersaturated vapour, and the new nuclei can be effective only when the defect of temperature amounts to tens of degrees. W. N. Y. K.

685. *Fuel Economy in Hand-fired Plants.* (Univ. of Illinois Engin. Experiment Station, Circ. No. 7 [89 pp.], April 1, 1918.)—This bulletin, compiled by a committee, presents suggestions to help those immediately concerned in working hand-fired boiler plants to effect greater fuel economy. The matter is grouped in nine sections. I. Introduction.—In Illinois State about 6,000,000 tons of bituminous coal are fired by hand annually, and it is believed that from 12 to 15 % of this can be saved by more economical working. II. Fuels available in the Middle West.—The varieties of fuel are classified and analyses tabulated. A map shows the distribution of the coal-fields. A chart gives the theoretical value of coals of different heating values at various prices per ton. Storage of coal and the necessary precautions are dealt with. III. Combustion of fuel.—Methods of firing, draught regulation, determination of CO_2, and gas sampling are discussed. IV. Features of the Boiler Installation.—Different boiler settings are described and illustrated by diagrams. V. Installation features concerning draught conditions: deals with stacks and breechings. VI. Feed-water heating and purification methods are described. VII. Steam-piping requirements are discussed; a diagram of a complete power plant shows the proportionate losses in different parts. VIII. Record of operation.—The requirements of a record are discussed and a specimen form is shown. IX. Summary of conclusions. W. N. Y. K.

686. *Boiler Furnaces and their Design.* **D. S. Jacobus.** (Power, 48. pp. 318–320, Aug. 27, 1918. Paper read before the Am. Boiler Manuf. Assoc., June, 1918.)—In boilers properly designed for high capacities the limit is set by the amount of fuel that can be burned, which is governed by the stoker and furnace conditions. The average distance from the floor line to the lower ends of the uptake headers in B. and W. boilers used to be from 6 to 9 ft.; this has now been increased to 10 to 14 ft. The larger furnaces give better conditions for combustion and tubes but lead to more difficulty in maintaining brickwork. The action of flames on the furnace

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walls is discussed. The admission of air above the fire, and thorough mixing of the gases in the furnace are considered. In addition to coal as fuel, oil, blast-furnace gas, and wood are dealt with in connection with the effect on the furnace. W. N. Y. K.

687. *Development of Power from the Standpoint of the Boiler-room.* **C. F. Hirshfeld.** (Power, 48. pp. 284–286, Aug. 20, 1918.)—Studies the distribution of losses that occur in the generation of power from coal and its delivery to consumers as electric energy. A chart shows the various losses segregated. The thermal and commercial efficiencies of boiler plant are considered with particular reference to a typical case. W. N. Y. K.

688. *Coal Conservation in the Boiler-room.* **R. H. Kuss.** (Amer. Soc. Mech. Eng., J. 40. pp. 848–849, Oct., 1918. Power, 48. pp. 322–328, Aug. 27, 1918. Abstract.)—Refers to the use of bituminous coal in the United States, and estimates the savings to be effected by making all possible increase in the efficiency of steam-raising. The necessity for proper draught conditions to obtain economical working is urged, and the means to obtain them are discussed. W. Y. N. K.

689. *Repairing Boilers by Arc Welding.* **R. S. Kennedy.** (El. Rev. 83. p. 176, Aug. 23, 1918. Abstract of paper read before the Inst. of Marine Eng.)—Tests made in 1909 of electrically-welded specimens showed an average tensile strength of about 17 to 18 tons per sq. in. Since then improvements in apparatus and methods have increased the tensile strength of welds in boiler steel to about 27 tons per sq. in. In practice, however, not more than 20 tons per sq. in. should be worked to, this giving a sufficient margin to allow for possible small defects in workmanship. In no single case has the author known an electric weld to give way suddenly; failure has always been preceded by a small crack, which has gradually developed. The tensile strength and tenacity of an electric weld is increased by 5 to 10 % by hammering, but it is essential that this should be done when the material is at welding heat. The iron wire used for melting in is of the very best material, with preferably a small quantity of Mn, and has a tensile strength of 28 tons per sq. in., with an elongation of 50 %. To provide against oxidisation, and also to increase the fluidity of the metal, it is usual to coat the metallic electrode with a flux. In welding over a riveted seam, rivets should be completely covered, and the landing edge should be caulked for some 6 in. at each end of the welded portion. Work can be carried on overhead or in any accessible position. A good job depends upon the conscientious work of the man. The materials at present dealt with commercially are wrought-iron, steel, cast-steel, and occasionally cast-iron. It is possible that there is a welding temperature of cast-iron, but the range of this temperature is very small, probably about 10 deg. C.

The voltage across the metallic arc is about 22 to 25 volts, an equal steadying resistance being used, making the voltage at the dynamo terminals about 45 volts. A substitutional resistance is employed which is put in circuit by an automatic switch when the welder breaks his arc, thus keeping the load on the machine constant. The current actually employed is about 175 amps., but the author uses machines designed for 250 amps. The preparation of a job for electric welding is important, and details are given of methods employed in various kinds of repairs. Arc welding is suitable for work over 3/16-in.; for thinner work one of the gas systems is preferable. R. J. W.-J.

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690. *External Wasting of Fuel Economiser Pipes.* **E. Ingham.** (El. Times, 54. p. 116, Aug. 22, 1918.)—The commonest cause of deterioration in fuel economisers is external wasting of the vertical pipes, frequently very rapid and leading to failure and explosion. The moisture and certain compounds in the flue gases form corrosive acids, so it is desirable to keep the tubes dry. Points required to ensure this are: (1) dry situation, (2) prevention of leakage from pipes or valves on to the economiser or its setting, (3) provision of means to drain away all water which may collect in the soot chamber, (4) keeping the inlet temperature of the water above 100° F. to avoid condensation of moisture in the flue gases.

The pipes which suffer most from external corrosion are those near the water inlet. External wasting may be discovered by calipering the external diameter of the pipes and comparing with the original diameter. Serious wasting may be detected by careful hammer tests. Internal corrosion may also take place, and this should be allowed for when measuring. In serious cases of wasting, a good idea of the state of surrounding pipes may be obtained by withdrawing one pipe and breaking it up. Contrary to a common impression, economiser explosions can have very harmful results. The application of hydraulic tests at a pressure from 50 % to 100 % in excess of the safety-valve load will often prove useful in discovering weakened pipes, if applied with discretion. W. N. Y. K.

691. *High Vacuum at the Turbine Exhaust.* **H. L. Smith.** (El. Rly. J. 52. pp. 99–101, July 20, 1918.)—Discusses the means of obtaining a high degree of vacuum at the turbine exhaust as distinct from the condenser. The mass and momentum of steam entering the condenser must be taken into account. In order that the steam at the exhaust nozzle may be cool, the cooling water must come into contact with it first. The contra-flow principle and its relation to the average thermal transmission coefficient stand in the way of progress. Such devices, as rain plates are now recognised as increasing the pressure drop in the condenser, creating a worse evil than they are designed to obviate. The effect of the presence of air is treated of generally. W. N. Y. K.

GAS, OIL, AND WATER ENGINES.

692. *Air Propulsion.* (Am. Soc. Mech. Eng., J. 40. pp. 676–681, Aug., 1918. Disc.)—[For **M. Brooks's** paper see Abs. 474 (1918)]. **N. W. Akimoff** said that the theory of superspeed due to batting action of the propeller blade on the air particles was not in accordance with the hydrodynamics of the problem, and he regarded the vortex theory of sustentation as giving the real solution of the problem. **C. W. Howell** said that the efficiency of an air screw appeared to depend largely on the design of the trailing edge of the propeller blade. **G. de Bothezat** described the theory of the action of a propeller blade on the air, introducing the conception of the "zero plane," *i.e.* that plane in which the impinging air produces a resultant in the same direction as itself. This zero plane does not contain the chord of the blade, but makes with the chord an angle which depends on the profile of the section, ranging from 3° to 12° for most sections. Angles of attack should be measured only from this zero plane, and the pitch of the sections should be measured from the zero line and not from the chord. This *effective pitch* is always greater than the *constructive pitch*, and this gives the explanation of the superspeed phenomenon. **L. R. Gulley** described tests on a propeller arranged with short blades of such width that the entire surface of the propeller was covered. **J. C. Hunsaker** considered that the theory

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of a rebounding effect was not in accordance with Prandtl's experiments and did not harmonise with the vortex theory of sustentation. There is a close agreement between propellers tested in water and those tested in air, as the compressibility of the medium is not a serious factor. **M. B. Sellers** considered that the superspeed effect might be regarded as following from the contraction of the jet due to a propeller. J. W. T. W.

693. *Wind Power for Electricity Generation.* **P. Schubach.** (Helios, 24. No. 17. 1918. Elektrot. u. Maschinenbau, 36. p. 385, Aug. 25, 1918. Abstract.) —The author calls attention to the rapid multiplication of wind-power installations in Denmark, and considers that their employment will become even more general in country districts as a result of the war.

Wind-velocity observations at Lindenberg Observatory have shown that in low-lying districts at sea-level the mean wind velocity is 4·7 m./sec.; at 500 m. this rises to 8·9 m./sec., and at 1000 and 1500 m. to 9·2 and 9·4 m./sec. respectively. The energy available, N, for the wind motor can be calculated from the formula $N = YFv^3/(150g)$, where F is the projection of the total wing surface in sq. metres, V the wind velocity in m./sec., Y the weight of 1 m.³ of air, and g the acceleration due to gravity.

The following table gives the relation between size and output of wind motors for wind velocities of 5 and of 7 m./sec. :—

Wheel Diam. in Metres.	F in Sq. Metres.	H.P. Developed at 5 m./sec. Wind Velocity.	H.P. at 7 m./sec. Wind Velocity.
2·5	2·9	0·16	0·6
3·5	5·2	0·3	1·0
4	7·2	0·5	1·5
5	11	1·0	2·5
6	16·7	1·5	4
7	22·4	2·0	5
8	28·8	2·5	6
10	44	4	8
12	65–6	6	14

Reference is made to the wind motors of the G. R. Herzog Saxon Steel Wind-Motor Co., of Dresden. In these the dynamo is driven by means of gearing and countershaft. Auxiliary wind wheels serve for rotating the main wheel according to the wind's direction and for adjusting to the wind's intensity. The main wheel is mounted on a wooden or iron tower in such a way that the lower edge of the wheel clears by 2 or 3 m. any obstacles there may be to the wind over a radius of 200–300 m. The irregular working of such a motor necessitates the use of a storage battery to work in parallel with the dynamo, and this battery should be capable of supplying two days' current requirements. The cost of operation is given as 4 to 7 pfennigs per h.p.-hour, or 120 to 210 shillings per h.p.-year, including interest, amortisation, and attendance.

Two suitable regulators are then described : these appear to be of the usual type, namely, an automatic cut-out operating when the speed falls below a certain value, and a voltage-regulating centrifugal governor which operates the field resistance of the dynamo. L. H. W.

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PROPERTIES OF ENGINEERING MATERIALS.

694. *Report of Committee on Limits and Tolerances of Screw Threads.* (Am. Soc. Mech. Eng., J. 40. pp. 661–675, Aug., 1918.)—It is thought that three grades of gauges should be established, namely: (1) For more general work; (2) for more restricted, and (3) more liberal tolerance respectively. Here only general work is dealt with. The type of screw considered is the American V-thread, truncated at root and crest; and the range of diameters is from ¼ in. to 2 in.; but the formulæ given can be used for sizes beyond this range. Tables of tolerances for screws and taps between these limits are given. The report includes an account of gauging systems and micrometers for measurement of screw diameters and pitch; but the accuracy attained in these instruments is such as would be used in ordinary workshop practice, and is only, say, 1/1000 in. P. E. S.

695. *A Cause of Failure in Boiler-plates.* **W. Rosenhain and D. Hanson.** (Iron and Steel Inst., J. 97. pp. 313–324, 1918. Engineering, 105. pp. 692–694, June 21, 1918.)—The results of an investigation of the cause of failure in a boiler-plate which cracked during the last stage of manufacture are given. The plate had been submitted to bending operations in stages in the cold, and to intermediate annealings between the various stages. The cracking occurred during the straightening of the edges after the bending operations had been completed. Chemical analysis indicated mild steel of high quality and tensile tests showed nothing unusual except a comparatively large difference between the elastic limit of the yield stress. Impact tests on the Charpy machine gave only 0·75 kg.-metre per cm.²; after annealing at 550° C. the impact test gave 2·90 and after normalising at 900° C., 11·2.

As a result of further examination it was concluded that the low impact figure given by the plate as received was due to the development of coarse ferrite crystals in carbonless bands in the plate, and these were the result of low-temperature annealing, following upon deformation in the cold.

C. O. B.

696. *High Cooling and Rolling Stresses in Steel Rails.* **J. E. Howard.** (Eng. News-Record, 80. p. 812, April 25, 1918. Paper read before the New England Railroad Club, Jan., 1918.)—Stresses of 18,000 to 20,000 lbs. per sq. in. exist in steel rails when no load is on the track. These stresses include those developed by the cooling of the rail after the last pass in the mill and those resulting from deformation brought about by the rolling stock. Compression stresses exist in the flanges and the periphery of the head, while tensile stresses occur along the junctions of the web with the base and the head. In service, the compression stresses in the skin of the head are greatly increased and the stresses produced with light wheels penetrate deeper than those produced with heavy wheels. The web is little affected by the rolling influence, but stresses may be set up by the mechanical production of permanent strains round the bolt-holes. The base of the rail is only slightly affected. F. C. A. H. L.

697. *Permeability of Balloon Fabrics.* **J. D. Edwards.** (Bureau of Standards, Technol. Papers, No. 113. [31 pp.], Washington, 1918.)—Describes the various methods hitherto employed for determining the permeability to

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hydrogen of balloon fabrics. These may be classed as (1) volume-loss methods in which measurement is made of the rate of decrease of volume of a mass of hydrogen separated from the atmosphere by a definite area of fabric, and (2) penetration methods in which the volume of hydrogen passing through a definite area of fabric in a given time is measured either chemically, by igniting and weighing the resulting water, or optically by means of the Rayleigh-Zeiss interferometer. The penetration method is that employed for standard work, and by its means the effect of humidity, change of temperature, and alteration of pressure has been studied—the last-named effect being found negligible after the first small increase of pressure. The permeability being due to the solution of the gas in the rubber of the fabric, the influence of the duration of the test has also been investigated. On account of its comparative simplicity, the volume-loss method was experimented with and was found to give results varying from 66 to 74 % of those given by the penetration method. The absorption of hydrogen by rubber was the subject of a separate experiment. The results are expressed in litres of hydrogen (at 0° and 760 mm. pressure) passing through 1 sq. metre of fabric in 24 hours.

J. W. T. W.

698. *Effects of Heat on Celluloid and Similar Materials.* **H. N. Stokes** and **H. C. P. Weber.** (Bureau of Standards, Technol. Papers, No. 98. [89 pp.], Washington, 1917.)—The main conclusions arrived at are as follows :—

(1) The decomposition of nitrocellulose in celluloid commences in the neighbourhood of 100° C. Above this temperature the heat of decomposition may raise the temperature of the mass to the ignition-point, if loss of heat by radiation is prevented. (2) Above 170° the decomposition of celluloid takes place with explosive violence, as with nitrocellulose. (3) The rate of combustion is 5 to 10 times that of poplar, pine, or paper of the same dimensions and under the same conditions. (4) Celluloid articles may be ignited by momentary contact with bodies having a temperature of 480° or above, *i.e.* temperatures below visible red heat.

L. H. W.

699. *Deterioration in the Heating Value of Coal during Storage.* **H. C. Porter** and **F. K. Ovitz.** (Bureau of Mines, Bull. 186. [84 pp.], Washington, 1917.)—The Sheridan sub-bituminous coal tested is found to lose 8 to 5·5 % of its heat value in about three years' storage, the greater part (70 to 80 %) of this loss being in the first nine months. During the period of 2¼ years the deep bins suffered the greatest loss, probably because their sides offered greater surface for access of air than those of the small bins. The latter became covered with a 12-in. layer of fine slack that helped to protect the layers beneath from oxidation. The use of air-tight bottoms and sides (of concrete) is advocated, and the accumulation of a protecting layer of fine slack on the surface. The deterioration in heat value can probably in this manner be kept below 8 % in one year, and will probably not increase to more than 4 % in two or three years if the coal remains undisturbed.

L. H. W.

700. *Recovery of Gasoline from Natural Gas by Compression and Refrigeration.* **W. P. Dykema.** (Bureau of Mines, Bull. 151. [117 pp.], Washington, 1918.)

701. *Bibliography of Petroleum and Allied Substances,* 1915. **E. H. Burroughs.** (Bureau of Mines, Bull. 149. [121 pp.], Washington, 1918.)—

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This bibliography, which is intended to be the first of a yearly series, comprises 1455 entries and is preceded by an explanation of the scheme of subject classification made use of. L. H. W.

702. *Extraction of Gasoline from Natural Gas by Absorption Methods.* **G. A. Burrell, P. M. Biddison** and **G. G. Oberfell.** (Bureau of Mines, Bull. 120. [66 pp.], Washington, 1917.)

703. *Oil-storage Tanks and Reservoirs.* **C. P. Bowie.** (Bureau of Mines, Bull. 155. [70 pp.], Washington, 1918.)—This monograph includes a brief discussion of the losses of oil during storage and of methods of preventing such losses. L. H. W.

704. *Potash from Blast-furnace Gases.* **A. L. Leigh, K. M. Chance.** (Iron and Coal Trades Rev., Jan., 1918. Met. and Chem. Eng. 18. pp. 420–421, April 15, 1918. Abstracts of two papers read before the Cleveland Inst. of Engin.)—The first, by A. L. Leigh, described the installation of a gas-cleaning plant at the North Lincolnshire Iron Co.'s Works, and stated that savings were effected both in the boilers and stoves by use of the *cleaned* gas. The author summarised the advantages due to cleaning, as follows:—(1) Economy in gas for boilers. (2) Economy in gas for stoves. (3) Fewer stoves required and probably fewer boilers. (4) Better control of furnace operations and saving in cleaning stoves, boiler-flues, etc. (5) Additional source of income from the larger volume of spare gas, of an increased value, for the production of cheap power and coal-economy. (6) Recovery of potash as a by-product.

The second paper, by K. M. Chance, dealt with the commercial aspects of the recovery of potash from waste blast-furnace gases. He said with the present rate of pig-iron production in England, it might be estimated that not less than 200,000 tons of potash are being fed into the blast-furnaces each year. Of this, in round figures, three-quarters (or 150,000 tons) passes through the furnaces and away in the slags in insoluble form, and one-quarter (or 50,000 tons) is volatilised and carried from the furnaces in the gas, in the form of carbonate, chloride or cyanide, usually a mixture of all three. Of this 50,000 tons, a small proportion is carried down into the dust-catchers and down-comers with the heavy dust, and another small proportion is recovered from the stoves and boiler-flues, after the combustion of the gas, in the form of sulphate of potash, into which it has been converted during the process of combustion. The remainder, which may be estimated as being in the neighbourhood of four-fifths of this 50,000, escapes with the gas up the chimneys, and is liberated into the atmosphere. Of all the potash charged into the furnaces, therefore, at the present time, not more than 5 % is recovered, and of that 5 % quite a considerable proportion is thrown away with the heavy dust as having no value.

The British Cyanides Co., Ltd., and the North Lincolnshire Iron Co. have carried out a long series of experiments on a practical scale, and have devised two methods of recovery. One process aimed to volatilise the potash from the furnace as carbonate, but is not recommended as a commercial method. A simpler and more economical method of recovering the potash charged into a furnace manufacturing ordinary pig-iron, is by adding to the charge an alkaline chloride, of which common salt is the one most readily available. This has the effect of converting the silicates of potash into chlorides, which are volatilised at ordinary working-temperatures into the gas in that form, substituting soda for potash in the slags; and there is ample evidence to

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show that, generally speaking, this method can be relied upon to render available for recovery, from 70 to 80 % of the potash charged into the furnace, in contrast to the bare 5 % now recovered.

The author stated that a company had been formed, called the British Potash Co., Ltd., the shareholders in which are the two firms mentioned, John Lysacht, Ltd., and the Government.

After careful consideration it has been settled that the smallest unit, consistent with economy, is a factory whose output will be not less than 25,000 tons of potassium chloride per annum. The first of these factories has been erected at Oldbury. If this factory is successful, it is expected that similar ones will be erected in other iron-smelting districts, starting with the Cleveland district of Yorkshire. J. B. C. K.

705. *The Wet Thiogen Process for recovering Sulphur from Sulphur Dioxide in Smelter Gases.* **A. E. Wells.** (Bureau of Mines, Bull. 133. [64 pp.], Washington, 1917.)—The thiogen process has been described in Abs. 822 (1917). This monograph is a critical study of the wet process. A 10-ton plant for this, based on cost of material in 1913, would cost $40,000 and would be able to produce sulphur at a cost of $18 per ton. L. H. W.

706. *Advantages resulting from a Throttle-piece at the Inlet of Reservoirs destined to Diminish Water-hammer.* **de Sparre.** (Comptes Rendus, 167. pp. 115–118, July 16, 1918.)—The paper is entirely mathematical and proves that for a given pipe and a given value of water-hammer, a definite reduction in the volume of the reservoir can be brought about by a given throttle. The reduction of the kinetic energy in the water due to the compression is shown to be a definite fraction of the initial kinetic energy, so that the water oscillations are almost completely suppressed and the dangers of resonance eliminated. H. H. Ho.

707. *Electrolytic Pickling and its Effects on the Physical Properties of Iron and Steel.* **J. Coulson.** (Am. Electrochem. Soc., Trans. 32. pp. 237–248; Disc., 248–245, 1917.)—The brittleness of steel springs resulting from acid pickling and electroplating is a well-known phenomenon. Tempered springs which are pickled even for a few seconds in an acid bath, snap when subjected to strain; such springs, however, can be electrolytically pickled without destroying their resiliency. This paper describes an electrolytic process for removing oxides from the surface of iron, steel and other metals, without impairing their physical properties. In order to determine the embrittling effect of absorbed hydrogen upon steel pickled in different ways, samples of spring-steel wire were pickled chemically by simple dipping in acid, also by electrolytic pickling, using them as kathodes or anodes. Oscillation tests on the original wires, the same sand-blasted, and the three sets treated as described, showed the chemically cleaned and the kathodically cleaned to be very brittle, while the *anodically* cleaned had the strength of the original samples. Similar tests were also made with drill-rod steel, hot-rolled Bessemer, and cold-rolled steel, after which mechanical tests were made as to strength, elongation, and reduction in area. The chemically and the kathodically cleaned specimens again showed greater brittleness, which was most marked with the high-carbon steels and less marked with the soft steel. J. B. C. K.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

708. *The Future of Electrolytic Zinc.* **T. French.** (Am. Electrochem. Soc., Trans. 32. pp. 321–328; Disc., 328, 1917. Met. and Chem. Eng. 17. pp. 647–649, Dec. 1, 1917.)—In the last two years a large quantity of high grade electrolytic zinc has been produced in the United States and Canada, and at the present time many other plants are projected. In view of this rapid progress the question has often been asked: Will the older retort process of smelting be superseded by the electrolytic deposition of zinc? The reply to this question is generally given in an unqualified negative, apparently justified by the rather unsatisfactory recoveries of zinc obtained by those who have adopted the electrolytic process. The poor recovery is attributed mainly to the difficulty of roasting the ore without the formation of ferrate of zinc, which is very difficult to dissolve in the acid effluent from the electrolytic vats, but also to the difficulty in dealing with the filtration of slimy acid and neutral solutions.

In this paper the author discusses the comparative merits of the retort process and the electrolytic process of extracting zinc from its ores, particularly considering the cases of concentrates and of lead-bearing zinc ores. The conditions for satisfactory roasting preliminary to leaching are considered, also the leaching process, and the conditions for depositing pure zinc, as determined by the purity of the electrolyte. Detailed costs of the electrolytic process are finally given, as compared with the retort process treating the same ore, and proving that the former method has, in the author's opinion, a good prospect of ultimately superseding the latter. J. B. C. K.

709. *Electrolytic Recovery of Copper and Sulphuric Acid from Copper-Mill Pickling Solutions.* **J. L. Jones.** (Am. Electrochem. Soc., Trans. 32. pp. 229–236, 1917.)—In the rolling of copper it is necessary to remove the copper scale that is formed in the various heating and annealing operations, for if this is not done the scale is rolled into the copper, giving a rough surface. Another reason for removing the scale is the fact that it is an abrasive, and where copper is drawn into bars, strap, or wire, the dies would soon be ruined if the scale were not removed. The pickling of copper is carried out in large lead-lined wooden tanks, using a solution of dilute sulphuric acid heated by waste steam. When the rate of pickling becomes slow, due to the solution becoming saturated with copper sulphate, more acid is added, and the tanks are often run until supersaturated.

Two chemical methods have generally been followed by manufacturers for utilising the waste pickle, after it has ceased to be satisfactory for cleaning copper, and a third has now been devised and put into operation. The new method is an electrolytic one, and not only is the copper extracted in a pure condition fit for remelting, but the acid is regenerated and rendered available for further use. The following are details of a plant of this character erected by the Westinghouse Electric and Manufacturing Co. in its new copper-mill.

The pickling is done in two lead-lined wooden tanks, each 16 ft. long, 4 ft. wide and 3 ft. deep, holding 1,300 galls. each. A few galls. per min. of the pickling acid is allowed to flow by gravity from the pickling tanks and is lifted by a steam siphon to the first one of the series of recovery tanks. These are five in number, and are each 6 ft. long, 3½ ft. wide,

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and 4½ ft. deep; they hold 535 galls. each, and are lined with 7-lb. sheet lead. Another smaller tank holding 220 galls. serves as a storage tank or sump. The sump receives from the last recovery tank an amount of regenerated acid equivalent to the amount of pickling acid received by the first recovery tank. The regenerated acid in the sump is returned by a steam siphon to the pickling tanks, thus completing the cycle.

Very good electrolytic results are obtained through continuous operation, keeping the acid content at about 14 % and the copper at 3½ %. At present, however, the plant is operating intermittently, regenerating the acid content rather high (about 20 %) and running the copper down to about 1 %. The recovery tanks are arranged in cascade, and are set in a cement-lined pit provided with a sump to take care of any leakage. The series system is used, with parallel circulation across the face of the electrodes. Rubber connectors, so made that they may be easily slipped-off and replaced, connect the tanks with each other. Current is supplied by a 60-volt, 1000-amp. generator, which has capacity for a considerably increased production. The data for the preliminary operation of the plant are not very complete, but are sufficient to show fairly satisfactory results. The plant has been run 60 days of 10 hours each, using 65 kw. or a total of 1600 kw.-days. There was recovered 3355 lbs. of copper and in addition 420 lbs. of copper was plated upon 519 steel plates, making a total of 3775 lbs. of copper recovered. This is slightly less than 1 lb. of copper per kw.-hour. The amount of acid recovered was about 5500 lbs. The most marked advantage, however, was the increased rapidity of the pickling operation; the amount of copper pickled in the time mentioned was 2,714,594 lbs. Without the recovery plant it would have been necessary to increase considerably the capacity of the pickling-tanks, to do this amount of work.

Using three tanks in series, and a current of 1000 amps. at 2 volts, 155 lbs. of copper and 200 lbs. of acid are recovered daily, showing an ampere efficiency of 72 %. By adding additional tanks the output of the plant can be increased to 1200 lbs. of copper and 1800 lbs. of acid, as the generator has a capacity of 60 kw. J. B. C. K.

710. *Electrostatic Precipitation.* **O. H. Eschholz.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1293–1306, Aug., 1918.)—A summary is given of the various commercial processes of precipitating solids held in suspension in gases. Particular attention is given to the action of mechanical rectifiers and the effect of using long-arc and short-arc contacts. The rectifiers have the property of rapidly removing short-circuits that occur in the precipitation chamber. Oscillograms that are reproduced show that the clearing of a short-circuit takes place in less than 1/120 sec., and that on this account it is possible to work the precipitation chamber continuously within 1 % of the breakdown voltage. A list is given of a number of problems that still require investigation to improve the processes of precipitation. A. J. M.

711. *Electric Power for Nitrogen Fixation.* **E. K. Scott.** (Am. I. E. E., Proc. 37. pp. 779–820, July, 1918.)—The author compares the direct arc process for making nitric acid with the indirect cyanamide process. It is shown that the arc process is much simpler and the suggestion is made that a number of plants making nitrates by this process should be erected at existing power-houses, working with off-peak power. A plant of 10,000 kw. is considered suitable. Transportation would thus be reduced. A diagram is given showing the lay-out of by-product coke-oven plant with an

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electric power-house worked by the surplus gas, and an arc plant. The nitric acid made by such a plant would be about the amount required to combine with the ammonia to form ammonium nitrate. W. R. C.

712. *Resistance Type of Furnace for Melting Brass.* **T. F. Baily.** (Am. Electrochem. Soc., Trans. 32. pp. 155–163; Disc., 163–164, 1917.)—In the furnace here described the bottom of the chamber is so formed as to make a bowl-shaped hearth, and the resistance element is contained in a circular trough made of a refractory material similar to carborundum fire-sand. The resistance material is composed of broken carbon, which makes contact with electrodes placed diametrically opposite each other. The power consumption compares favourably with the crucible or open-flame melting furnace costs, the average being 450 kw.-hours per short ton of bearing bronze and 811 kw.-hours per short ton of cartridge brass. In the *discussion*, **H. W. Gillett** drew attention to the fact that although by continuous running the figures show that the consumption might come down to 275 kw.-hours per ton, this does not take into account the keeping hot of the furnace during the night under the conditions shown by the author. W. R. C.

713. *The Condensation of Zinc from its Vapour.* **C. H. Fulton.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1875–1894, Aug., 1918.)—The study of the condensation of zinc from its vapour was undertaken by the author in order to shed light on certain problems encountered in large-scale electric zinc-furnace work. One of the disadvantages of the arc-type electric zinc-furnace, is the production of a large amount of blue powder and proportionately little liquid spelter. The object of the experimental work was to determine certain fundamental facts in the distillation and condensation of zinc, in order to find an answer to the question: Are any products formed during the distillation of zinc ore and the subsequent condensation of the zinc vapour which interfere with the condensation to liquid metal; if so, what are they, and in what proportion are they harmful?

The results of the investigation show that under proper conditions there is nothing to interfere with the condensation of the zinc to liquid metal, but that the latitude within which operations may be carried on is not wide. One requisite is that the distillation and condensation systems must be tight and impervious to air. This, of course, has been well known, but the fundamental reason for it has not been recognised. Many of the electric zinc-furnaces that have been experimented with or proposed suffer from this vital defect, the arc furnace being particularly defective on this point. If operated continuously, by feeding ore and reduction carbon and discharging slag, there will be regions in the furnace, in the cooler portions above the smelting arcs, where CO_2 will form in considerable proportion, according to the principles discussed in this paper. For an electric zinc-smelting furnace to be successful, it must be able to obtain a uniform temperature rapidly throughout its whole distillation chamber; certainly no part of the chamber or its contents should be below 950° to 1000° C. From the standpoint of the condensation of vapour, it is not possible to distil at 1200° C. in one part of the chamber while the products of distillation come in contact with the ore charge at below 1000° C. in another part, and at the same time condense a large proportion of the vapour to liquid spelter. J. B. C. K.

714. *Steel from Nickel-Copper-Iron Ore.* **R. W. Leonard.** (Eng. News-Record, 80. p. 812, April 25, 1918. Paper read before the Canad. Soc. of Civ.

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Eng., March, 1918.)—The average percentage analysis of weathered Sudbury ore shows Fe, 46; Ni, 1·3; Cu, 0·28; SiO_2, 19·9; Al_2O_3, 8·8; S, 1·5 to 8; CaO, 2·7; and MgO, 1·8 %. After electric smelting a pig iron is produced containing 3 % C, 2·2 % Ni, 0·4 % Cu. From this pig, steel has been produced containing from 0·17 to 0·73 % C and a combined Ni and Cu content ranging from 1¼ to 2¼ %, the copper usually being about ¼ of the total. This product has been called "Nicu" steel and can be produced at £16 to £17 per ton. A typical mechanical test of an alloy in which the combined Ni and Cu was 2·26 % showed a yield stress of 52,800 lbs. per sq. in., an ultimate stress of 96,500 lbs. per sq. in. and a contraction of 57 %, as compared with a specified yield-point of not less than 50,000 lbs., an ultimate stress of 85,000–100,000 lbs. per sq. in., with a reduction of over 30 %, for a 3½ % nickel steel. Nicu steel has not yet been manufactured on a commercial scale. F. C. A. H. L.

715. *Mechanical Device for Transformation of Coordinates.* **O. Srnka.** (Elektrot. u. Maschinenbau, 36. pp. 155–157, March 31, 1918.)—Functions following a harmonic law may be represented in the forms $A.e^{j\alpha}$ or $p + jq$. The device described enables transformations to be easily effected from the (A, α) system to the (p, q) system, or *vice versa*. It is based on the relations $p = A\cos\alpha$ and $q = A\sin\alpha$ and consists of three graduated straight scales and a graduated sector provided with verniers. Two of the scales (on which p and q are read off) are at right angles and capable of relative motion at this fixed angle; the third scale (on which A is read off) is hinged at one end of the p scale, and its angle α with the p scale is read on the quadrant. Transformations from one of the systems to the other are reduced to the simple operation of reading off values on the scales. A. J. M.

716. *Harmonic Analysis of Oscillograms.* **G. H. Cole.** (Elect. J. 15. pp. 258-268, July, 1918.)—The analysis of wave-shapes by the type of analyser referred to with polar oscillograph attachments has been described by L. W. Chubb [Abs. 1023 (1914)]. The results are now given of an application of the apparatus to some special cases. A. J. M.

717. *Standardisation of Rare-metal and of Base-metal Thermo-couples.* **P. D. Foote, T. R. Harrison** and **C. O. Fairchild.** (Met. and Chem. Engg. 18. pp. 343–348, April 1, and pp. 403–409, April 15, 1918.)—Deals with the equipment of a pyrometric laboratory for industrial purposes and with the more general measurements that have to be made. L. H. W.

718. *Scope and Application of the National Electrical Safety Code.* (Bureau of Standards, Circ. No. 72. [84 pp.], Washington, 1918.)

719. *Extra Losses by Distortion of Current Flow in Conductors carrying Alternating Current.* **F. Niethammer.** (Elektrot. u. Maschinenbau, 35. pp. 17–20, Jan. 14; 32–37, Jan. 21, and pp. 44–47, Jan. 28, 1917.)—The author determines the losses in parallel conductors in air carrying alternating currents, taking into account the increase of the losses caused by the distortion of the lines of current flow. The calculations are made for conductors of round and rectangular section, and for various relative positions of the outgoing and return conductors. Cases are also considered for subdivided circuits consisting of numbers of conductors carrying the current in parallel. The results are applied to copper and iron conductors. A. J. M.

720. *Surges in Coils.* **W. Rogowski.** (Archiv f. Elektrot. 6. pp. 377–388, 1918. From the Physikal.-Techn. Reichsanstalt.)—In a previous article

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[Abs. 577 (1918)] the author has considered the question of the electric surges that occur when a coil of two turns is switched on to a battery over leads (1) of very small, and (2) of very great length. The case is now examined when the leads are of medium length. As a special case, it appears that particularly high voltages are generated when the length of the leads is equal to that of the long sides of the coil, the ends of the coil being assumed to be short-circuits between the sides. The phenomena are discussed for various ratios between the magnitudes of the characteristics of the coil and of the line.

A. J. M.

721. *Pre-charged Condensers in Series and in Parallel.* **V. Karapetoff.** (Am. I. E. E., Proc. 37. pp. 509–517, May, 1918.)—A condenser is charged from a source of direct voltage, and then is used as a booster in series with this source to charge another condenser. By repeating this process a large number of times the second condenser is finally subjected to twice the voltage of the source. This is the principle of the Delon apparatus for testing cables [Abs. 45 (1918)], and is explained in a numerical example. Then the more general case of two or more "pre-charged" condensers in series is considered, when these condensers are connected to some source of direct voltage; it is shown how to determine the final distribution of voltages among them. A similar problem is solved for pre-charged condensers in parallel. Finally a general network of pre-charged condensers is considered, and equations are derived similar to Kirchhoff's laws, from which the final distribution of voltages and charges may be computed, knowing the initial distribution. AUTHOR.

722. *Iron Loss due to Hysteresis.* **M. Latour.** (Rev. Gén. d'Él. 4. pp. 86–87, July 13, 1918.)—The hysteretic angle (the phase angle between the current and the flux) is considered with reference to the Steinmetz coefficient [see Abs. 402 (1918)]. The following expression is obtained for the hysteretic angle, on the assumptions that the current and flux waves are sinusoidal and the hysteresis loop elliptical: $\text{Sin } \theta = 4\mu\eta/B^{2-n}$, where μ is the permeability, B the flux density, η the Steinmetz coefficient, and n the hysteretic index.

It is shown that as B tends to zero, *i.e.* on the initial portion of the magnetisation curve, the value of n must approach 2, if $\sin\theta$ is not to exceed unity. When $n = 3$, the loss due to hysteresis vanishes. This case is cited with reference to homopolar machines and frequency-changers. N. W. M.

723. *Determination of Electric Fields of Insulators by the Electrolytic Method.* **W. Estorff.** (Elekt. Zeits. 39. pp. 53–55, Feb. 7; 62–67, Feb. 14, and pp. 76–78, Feb. 21, 1918.)—The author describes an electrolytic method which he has used for investigating the electric stresses on insulators. The method is based upon the similarity existing between the representation of the lines of the electric field and the lines of current-flow in an electrolyte. The equipotential lines between two electrodes are obtained by means of a probe, using a Wheatstone bridge and telephone; alternating current is employed in order to get rid of polarisation effects. The probe forms the tracer of a pantograph arrangement by means of which the equipotential surfaces can be traced out on an enlarged scale. The method is first applied to the examination of a suspension insulator, and, as an example of the utility of the method in aiding the design of insulators, it is shown how the distribution of the field is changed by altering the insulator from (1) a chain of 4 similar insulators with equal discs, to (2) a similar chain, but having enlarged end discs, and (3) a similar chain, but having increased capacity of the end members, and (4) a similar chain, but combining both modifications (2)

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and (3). The electric field diagram shows the more equally distributed field obtained by arrangement (2) as compared with (1); but this advantage is obtained at the expense of increased total capacity, which means that a larger number of lines of force terminate on the end plates, which results in diminished dielectric resistance.

Experiments on a series of carbon discs are next described and the fields obtained with 4, 5, 6, and 7 discs are reproduced. A similar arrangement of up to nine suspension insulators was then exposed to a high-tension test, and it was found that when the first sign of brushing appeared on the chain, the partial voltages and stresses on the end members were independent of the *number* of members in the chain and depended solely on the *shape* of the end members. L. H. W.

724. *Standardisation of Carbon Brushes.* (Rev. Gén. d'Él. 4. pp. 115–119, July 27, 1918.)—Following upon its work in standardising motor shaft ends, and angular speed of turbines driving alternators, the Chambre syndicale des Constructeurs de gros matériel électrique now publishes four plates showing standard dimensions in mm. for carbon and graphite brushes, pure or metallised, for use in electrical machinery other than traction motors. Letterpress accompanying the plates gives rules concerning dimensions of bevels and flexibles, tolerance and marking of brushes. These schedules came into force on July 1 last. The aim is to guide future construction, not to standardise existing material. The standardisation applies only to dimensions, not to materials. The brushes dealt with are those for *pinces* Thury and Thomson-Houston; brushes for box-holders; and brushes for reaction holders. The designer is left free choice as to the type of brush to be used in any particular machine. The scheme followed is simple and practical and its results, it is considered, should be important. R. E. N.

725. *High-efficiency Waterworks Pumps.* (Power, 48. pp. 16–17, July 2, 1918.)—Electric drive is most convenient for many pumping installations and the load is a good one from the central station point of view, operation being either continuous at full load or during periods of light load only. The fact that the pumps are driven by power purchased through a meter leads to higher efficiency being maintained and soon recoups the cost of the pumps. The table gives leading particulars of tests on two 12-in. centrifugal pumps driven by synchronous motors of the rotating field type. The guaranteed overall efficiency ("wire to water") was 74·3 % at heads of either 158 or 171 ft. and 73·7 % at 140 ft. The motors are wound for 2200 volts, 3-phase 60 cycles and drive the pumps at 1200 r.p.m. The pumps are of the single-stage, double suction volute type with 12-in. suction and discharge nozzles and no diffusing vanes. The latter would add to the cost and complexity without improving the efficiency.

	Motor No. 1—Pump No. 1.				Motor No. 2—Pump No. 2.			
Total head, ft.	143	159	172	186	143	158	170	178
R.P.M.	1220	1220	1220	1220	1220	1220	1220	1220
Galls. per min.	6771	5900	5035	3194	6527	5722	4930	4097
Overall efficiency...	78·4	78·3	77·7	67·7	78·0	77·5	76·4	72·8
B.H.P.	299	290	269	210	289	281	262	239
Pump efficiency ...	82·2	82·1	81·2	71·5	81·8	81·5	80·7	77

R. E. N.

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GENERATORS, MOTORS, AND TRANSFORMERS.

726. *Ventilation Systems for Steam-turbine Alternators.* **E. Knowlton and E. H. Freiburghouse.** (Gen. El. Rev. 21. pp. 240–246, April, and pp. 867–872 May, 1918.)—Part I surveys the evolution of ventilating systems for alternators. The relative heat losses per lb. of active material in alternators of different capacity and speed are represented thus :—

KV.A.	Speed, revs. per min.	Relative Heat Loss.
7500	97·3	1
18,750	720·0	4
25,000	1800·0	6

Excessively high temperature, and also dirt, shortens the life of insulating material ; an ample supply of cool clean air is therefore necessary. A curve shows the percentage of rated load as a function of the entering air temperature in the case of the present design of horizontal solid rotor alternators, 40° C. being the standard temperature. The quantity of water-vapour, even in saturated air, is too small to have an appreciable effect on the thermal capacity of the mixture. A diagram of a ventilation system for a turbo-alternator is given ; it is arranged to admit and discharge the air either wholly or partly inside or outside the turbine-room. The design of dampers and ducts is considered. The effect of dirt is shown by the temperature rise, *e.g.* :—

Machine No. 1 armature winding : dirty, 54 ; clean, 37.
Machine No. 2 armature core : dirty, 54 ; clean, 41.

Air humidifiers are discussed and curves given showing the sizes of air washers for various quantities of air, and for alternators of various capacities.

Part II deals with the humidity of the air, its determination, and the effects on machinery. The method of working the system to obtain the best results is described. In conclusion, it is pointed out that the essential feature of moisture prevention in the alternator is the avoidance of reduction of the air temperature at any point where water is objectionable. W. N. Y. K.

727. *Direct-current Generator for Constant Potential at Variable Speed.* **S. R. Bergman.** (Am. I. E. E., Proc. 37. pp. 1011–1018, Aug., 1918. El. Rev. 83. pp. 335–336, Oct. 1, 1918.)—The machine described has a series-wound armature and a field with twice the number of poles as that for which the armature is wound. The illustration shows a 2-pole armature in a 4-pole field, the field poles producing two fluxes, one at right angles to the other. The commutator has 3 brushes, two across a diameter in the direction midway between the two fluxes, and the other half-way between the two brushes just mentioned. The field windings producing the two fluxes are in parallel across the middle brush and one of the outer brushes, one circuit being saturated and the other being unsaturated. The former generates the "main voltage" of the machine between the middle and one outer

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brush, and the latter generates the "cross voltage" between the middle and the other outer brush. The excitation is taken from the brushes giving the main voltage. The two fluxes are quite independent and variation in either affects only its own corresponding voltage. The external load is taken from the outer brushes, and the voltage across these depends on the difference between the main and the cross voltages. The interaction of the fields described and the armature reaction results in the generation of a voltage across the outer brushes that is independent of the speed of the machine. As the generator involves the use of the difference of two fields, it is larger than a standard machine of the same output, but at a sacrifice of about 10 % in efficiency it may be built so as to have the same weight as that of a standard machine. A. J. M.

728. *The Potential Generated in a High-tension Magneto.* **E. T. Jones.** (Phil. Mag. 36. pp. 145–169, Aug., 1918.)—This paper is chiefly concerned with an investigation of the potential generated in a magneto after the contacts have been separated. On the assumptions (1) that the resistances of the primary and secondary coils are negligible, (2) that the e.m.f.'s induced in these coils due to the rotation of the armature are constant during the short interval between break and max. potential, formulæ are derived for the max. potential, the frequencies of the two oscillations in the coils, and the coefficient of coupling. It is shown that there is only one frequency (*a*) when the primary is closed, *i.e.* the capacity of the condenser across the contacts is infinite (*b*) when this capacity is zero. In the latter case the primary and secondary oscillate as one coil.

Experimental curves are given showing the relation between the capacity of the condenser across the primary coil, and the max. secondary potential in the case of an induction coil. From these curves the optimum capacity for a given secondary coil can be determined. Similar curves have been determined experimentally for a magneto. These agree with the curves deduced from theoretical considerations, and also with the type of curve obtained for the induction coil.

The inductances, effective resistances, and coupling of the primary and secondary coils have been determined by oscillation methods. The effective resistances were found to be very much greater than the steady-current values, owing mainly to the iron loss, whilst the inductances were found to be much smaller than the steady-current values. From these measurements and the formulæ previously derived the capacity of the secondary coil is calculated.

The type of spark discharge is considered with reference to this capacity. Photographs illustrating pulsating arc and multiple spark discharges are given: also oscillograms showing the oscillations with the primary open and closed.

Finally the max. secondary potential is calculated from the constants of the coils as found by experiment. The max. potential is reduced by damping and by the difference in phase of the two oscillations. The potential generated, as estimated by the spark-length, falls short of the calculated value by about 25 %. This is attributed to (1) lag of the spark, (2) imperfect interruption of primary current, (3) the value of the inductances used in the calculation being larger than the values which obtain at the frequencies in the magneto.

The conclusion reached is that only a small proportion of the initial magnetic energy $1/2L\,i^2$ (L being the self-inductance of the primary coil for

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slowly varying currents) appears as electrostatic energy in the secondary circuit, and that the magneto, regarded as an arrangement for the production of high potential, is therefore a machine of low efficiency. N. W. M.

729. *Coil-end Leakage in Direct-current Machines.* **F. Unger.** (Elektrot. u. Maschinenbau, 36. pp. 161–165, April 7, 1918.)—The methods of Arnold and Hobart for calculating the leakage reactance of the coil-ends in d.c. machines, are based on approximations and on the average results of experiments. The author makes a more accurate calculation, and arrives at formulæ by which the value of the leakage reactance of any machine may be easily computed. A. J. M.

730. *Eddy-current Losses in Massive Armature Conductors at No-load.* **L. Dreyfus.** (Archiv f. Elektrot. 6. pp. 327–358, 1918.)—A considerable proportion of the core losses of a machine is often located in the conductors lying in the slots. The distribution of the slot field round the armature shows a wealth of higher harmonics even at no-load, and in consequence heavy eddy-current losses are produced in the embedded conductors. The calculations of the magnitude of these losses now given show that the eddy-currents react upon the flux density in the teeth, and that this reaction has the effect of setting an upper limit to the eddy-current losses. In fact, already with moderate depth of the embedded conductors, the eddy-currents force back the slot-leakage field into the teeth, so that the slot is freed more and more from the stray field, and the total copper losses decrease instead of continually increasing with the slot depth, as is commonly assumed. In conclusion, the author points out that the conditions at load are much more complex, and have hitherto not been cleared up by theory or experiment. Tests made at short-circuit are not adequate to elucidate this point, as only the armature leakage flux remains in the slots under this condition. On this account the investigations of Field may only be considered as giving a lower limit for the losses at full load. It is furthermore incorrect to add the no-load eddy-current losses to the short-circuit eddy-current losses in calculating the full-load losses, and there is room for the development of a theory embodying the theories set up for no-load and short-circuit. A. J. M.

731. *Large Single-phase Starting Motors.* **W. C. K. Altes.** (Gen. El. Rev. 21. pp. 436–440, June, 1918.)—A description is given of the design of a special motor for starting up a frequency changer consisting of a 25-cycle 10,000-kv.a. single-phase synchronous motor and a 60-cycle 3-phase generator. The 25-cycle starting motor was required for starting up when the 3-phase supply was not available. The difficulties in designing a motor of this nature are set out, and eventually the type adopted was a two-circuit series motor with 20 poles. Two narrow brushes were used per pole in close juxtaposition on the commutator, each brush being connected to a separate neutralising winding and field winding. Each of the circuits so formed was fed by a separate secondary winding of the main transformer. By this device the size of the commutator was halved. Two kinds of coils were wound on to the stator, so as to get different numbers of turns per pole. In order to moderate the initial torque a resistance controlled by contactors was connected between the secondary of the transformer and the motor. It is possible to design the motor in such a manner that it may be used to excite the generator after it has been started up. Calculations are made of the starting torque that can be developed by motors of this type. A. J. M.

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732. *Asynchronous Slip-ring Machines.* **M. Latour.** (Rev. Gén. d'Él. 4. pp. 291–296, Aug. 31, 1918.)—The article contains a summary of the various methods adopted by different inventors to improve the power-factor of slip-ring induction motors and to regulate their speed. The present article was suggested by a conversation regarding a recent article by Picou [Abs. 188 (1918)], and is related to a similar review of methods of compounding alternators by the author of the present article [Abs. 518 (1917)]. It is now pointed out that the cases of motors and of generators are closely related, and that the same diagrams may in many cases be taken to apply to either. Although asynchronous machines are only treated, the definition of such machines is so drawn up as to include certain motors that are able to run at synchronism as one of their speeds. The synchronous machine is taken to be characterised by the condition that its torque varies as a function of its speed, in contrast with the synchronous machine in which the torque varies with the relative position of the rotor and the revolving field. Motors with high power-factor and variable speed are divided into two groups: (*a*) The rotor is connected to auxiliary machines not connected to the line and running at speeds independent of that of the rotor; (*b*) the rotor is supplied from the line through auxiliary machines with commutators running synchronously with the rotor. Machines of the first type cannot run at synchronism, and act as motors or generators according as they run below or above synchronism; machines of the second type can run at synchronism, and can act as motors or as generators, both above and below synchronism. A. J. M.

733. *Circle Diagram of the Induction Motor.* **V. Genkin.** (Rev. Gén. d'Él. 3. pp. 981–988, June 29, 1918.)—A method is given for effecting in a simple manner the transformation of the circle diagram for the operation of an induction motor in such a manner as to allow for the resistance of the stator windings.

The simple diagram corresponding to the case of no stator resistance is first drawn, and it is easy to see during the course of the transformation whether the resistance of the stator will have an important influence on the characteristics of the operation of the motor or not. The transformation is obtained by a method of inversion. The principle of this inversion is based on a proposition given by the author in a previous article [Abs. 260 (1912)]. If a receiver R is supplied through an impedance Z from a voltage V, and if this voltage is regulated so as to give a constant voltage on R at different loads, then the extremity of the vector representing the voltage V will lie on a certain curve. If again the voltage V be kept constant, then the extremity of the vector representing the voltage on R will lie on another curve. These two curves are inverse curves with respect to the origin of the vectors, the power of the inversion being equal to the square of the voltage maintained constant in the two cases. A. J. M.

734. *Initial Current-rush of Transformers.* **M. Vidmar.** (Elektrot. u. Maschinenbau, 36. pp. 273–277, June 16, 1918.)—The high voltages, and saturation of modern transformers lead to initial conditions that cause excessive current-rushes to be produced, when switching them on in an unloaded state. The danger is greatest in the case of transformers of small sizes. If the resistance R of the primary winding be neglected, it is shown that the density of lines B in the iron at time t after switching on is given by $B' = B_0 + B_m[\cos \alpha - \cos(\alpha + \omega t)]$, if B_0 is the remanent saturation, B_m the

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max. saturation at normal running, and α the phase angle of the voltage when the switch closes. It will be seen that B_0 has an important effect on the transient densities reached and that the highest densities are obtained for the smallest values of α, *i.e.* the smaller the voltage at the moment of switching on. The most dangerous conditions hold when $\alpha = 0$, $\omega t = \pi$ and $B_0 = B_m$. When these relations are satisfied we obtain $B = 3B_m$. The current at 3-fold saturation would, however, be so great that the limiting effect of the primary resistance (hitherto neglected) would have to be taken into account. From a consideration of the effect of this resistance it is concluded that in the most unfavourable case the initial max. current-rush can only exceed the normal current in the same ratio as the line voltage exceeds the voltage drop in the primary windingat normal load. Accordingly the initial current-rush may be far higher than the short-circuit current. The limiting action of the primary resistance indicates that the distribution of the copper losses between the primary and secondary windings is not immaterial, and that initial current-rushes will be reduced by designing the transformers with an increasing proportion of the copper losses located in the primary winding. As the size of transformers increases, the flux increases with the square of the dimensions, the length of the magnetic path with the first power of the dimensions and the resistance drop amounts to a decreasing percentage of the applied voltage. Thus the greatest current-rushes are to be expected with the smaller sizes of transformers.

If the ratio of the initial current-rush to the normal current in the most unfavourable case is denoted by K, then for a transformer with ϵ % voltage drop in the primary winding $K = 200/\epsilon A$, where $A = \pi\nu F_i F_c/(10 l_i l_c)$, the symbols having the following meanings : ν the frequency, F_i, F_c the sections of the iron in one phase and of the primary copper of one phase, l_i the length of the iron path per phase and l_c the mean length of turn of the primary winding. Applying the formulæ to the cases of a 10-kw. and a 16,000-kw. transformer it is shown that the value of K is 28 for the former and 4·5 for the latter ; thus the large sizes are self-protecting. A. J. M.

735. *Special Transformer Connections.* **M. Vidmar.** (Elekt. Zeits. 39. pp. 281–283, July 18, and pp. 295–297, July 25, 1918.)—The usual forms of 3-phase transformers are not quite symmetrical. The differences between the three magnetic paths cause the magnetising currents to be unequal, and the situation of the centre core between the outer ones gives rise to a greater temperature-rise in the centre core. These differences may be removed to some extent by winding the cores with unequal numbers of turns. This affords a means of shifting the star-point of the transformer to any desired extent along the median line of the 3-phase vector triangle. In this diagram the angle between either of the outer phase voltages and the line voltage between the outer phases is called the voltage angle α. The angle has the value 30° in the balanced transformer. If unbalanced windings are used to balance the magnetising currents, it is possible to obtain a true neutral point by the addition of an auxiliary boosting winding on the middle phase to counteract the shift of the neutral point by the change in the voltage angle. The true neutral may also be obtained in an unsymmetrically wound transformer by zigzag connections between the halved 3-phase windings. It is shown that a decrease in the voltage angle involves an increase in the amount of copper and a decrease in the amount of iron, and *vice versa*. The unequal heating of the limbs is reduced by an increase of the voltage angle beyond 30°, which throws part of the winding of the central core on to the

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outer core, and by adjustment of the sections of the three cores equal magnetising currents may be obtained in the three phases. Thus the practical advantages of the unsymmetrically built 3-phase transformer become apparent. Balanced loading produces balanced currents, just as in the symmetrical transformer. If a be increased to 45° we obtain the particular case of the 2-phase/3-phase transformer of the Gesellschaft für Elektrische Industrie of Vienna, in which the 3-phase winding is composed of mesh-connected symmetrical windings and the 2-phase winding of star-connected unsymmetrical windings. A symmetrical 2-phase load produces an equalising current in the middle winding on the 2-phase side. The value of this current is determined. Other transformer connections, such as the Scott-connection are shown to be special cases of the unsymmetrical 3-phase transformer. This arrangement suffers from poor regulation on unbalanced load. The conditions may be improved in this respect by connecting the windings in zigzag in a manner described. An interesting zigzag connection is shown for a 3-phase transformer with all three phases unlike. Although the neutral point of the star-connected windings is displaced from its proper position, the neutral point of the zigzag connection is brought to the centre of gravity of the transformed voltages. A. J. M.

736. *"Hottest Spot" Temperature in Transformers.* **A. Still.** (El. World. 72. pp. 113–114, July 20, 1918.)—A formula is developed from which the temperature at the centre of the thickness of a coil side may be calculated from particulars of the coil and a knowledge of the temperature of the surface of the coil.

Arguing according to the laws of flow of heat it is shown that the difference of temperature T (in degrees C.) between the outside surface and the centre of the winding may be obtained from the current density d (in amps./sq. in.), the space factors a and b (giving the thickness of copper per inch length of coil measured in the directions of the length l and thickness t of the coil winding respectively), and k_a, k_b the thermal conductivity of the copper associated with the insulating materials in the two directions of flow. The formula given is $T = [0{\cdot}84d^2 . a . b . l^2] / [8 \times 10^6 \{k_a + k_b(l/t)^2\}]$ in which the thermal conductivities are given by $k_a = 10/[a + 3000(1-a)]$ and $k_b = 10/[b + 3000(1-b)]$. A. J. M.

737. *On the Division of Currents between Transformer Coils when Coupled in Parallel.* **P. Girault.** (Comptes Rendus, 167. pp. 159–161, July 22, 1918.)—When a single-phase transformer has several secondary coils connected in parallel, the currents in the coils are different, those coils which are closer to the primary winding having the larger current. The equations to determine the currents in these coils are given. Other equations deduced from them are found to be identical with the equations ordinarily given to find the skin effect in a conducting plane. The effect of this unequal division of the currents is to increase the i^2r losses of the transformer and this loss increases the more, the greater the number of the secondary coils. This problem is of importance to electro-metallurgists. The author indicates how to diminish these losses by a symmetrical grouping of the conductors. A. R.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

738. *Calculation of Transmission Lines.* **M. Latour** and **G. Viard.** (Rev. Gén. d'Él. 4. pp. 67–71, July 20, 1918.)—The calculation of transmission lines by the method of hyperbolic functions according to Kennelly is not greatly used in France. The method of Raymon S. Brown, as used in the United States, is based on the use of hyperbolic functions, but is put into a form more adapted to practical requirements. The method is described, and charts to aid the calculations are reproduced. (*Ibid.* p. 288, Aug. 24, 1918.)—A number of errata in the mathematical parts of the above article are pointed out. A. J. M.

739. *Calculation of the Propagation of Alternating Currents over Long Lines.* **P. Boucherot.** (Comptes Rendus, 167. pp. 77–80, July 8, 1918.)—The usual methods of calculating the distribution of current and voltage along transmission lines involve the use of partial differential equations of the second order or imaginary quantities. The object of the present article is to demonstrate a method of avoiding the imaginary quantities and of simplifying the mathematics so that only an ordinary differential equation of the first order has to be solved with one variable, the distance. This is effected by using the principle of the conservation of the real and imaginary power. A. J. M.

740. *Formation of an Artificial Neutral by Voltage Balancers.* **L. Dubar.** (Rev. Gén. d'Él. 4. pp. 182–186, Aug. 8, 1918.)—In systems of distribution it is often desirable to have different voltages at disposal for lighting and power. This may be effected by the aid of voltage balancers. The article is concerned with single-phase and 6-phase systems. The voltage balancers in these cases consist of transformers with the primaries connected as auto-transformers and the secondaries either in closed circuits or in zigzag with the primaries. For each arrangement the distribution of the currents is worked out for a load between the artificial neutral and one supply main, and the vector diagrams of the voltages show how the neutral point is displaced under load conditions. A. J. M.

741. *Transient Phenomena in Electric Supply Systems.* **E. W. Marchant.** (Inst. El. Eng., J. 56. pp. 445–455; Disc., 455–471, July, 1918. Electrician, 81. pp. 63–64, May 24, and pp. 89–90; Disc., 90–91, May 31, 1918.)—The author presents a number of oscillograms taken during the switching-on of transformers, induction motors, and high-tension cables, and also in paralleling large alternators and rotary converters. These oscillograms are supplemented by others taken in the laboratory with controlled moments of switching. A. J. M.

742. *The Production of Electricity by Steam Power.* **A. Dow.** (Am. Electrochem. Soc., Trans. 32. pp. 65–82; Disc., 82–85, 1917. Electrician, 81. pp. 555–557, Nov. 1, 1918. Abstract.)—Presents the status of the production of electric power from steam to-day. The three different meanings of "cost of power" commonly used are defined as referring to (1) Power generated at the dynamo terminals, (2) power output from the station, and (3) power delivered to the consumers. Some general historical

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notes are made on the improvement of plant efficiency culminating in the working of the Connor's Creek power-house of 1914 and 1915. Tables I, II, and III give the costs per kw.-hour net output for three periods of 12 months each. The special arrangement for making the maximum use of steam utilised by auxiliary plant consists of a separate turbo-generator to supply it with electric drive. The turbine exhausts into a condenser whose temperature is controlled according to the requirements of the feed-water. The correct choice of drive for auxiliaries is partly electric and partly steam. There is no economiser at Connor's Creek, but under the present conditions of coal price economisers would effect a saving of 4 %. Load factor, depreciation, fuel cost, water supply, effects of weather on transmission lines, gas fuel, gas engines, higher steam pressures, and pulverised fuel are considered. In the *discussion*, **F. A. Lidbury** said that after investigation of the subject by a number of people concerned at Niagara there was little or no tendency on the part of electrochemical industries to depart from water power to steam. [See Abs. No. 1049 (1915).]

Table	I	II	III
Period.	12 Months ending June 30, 1916.	12 Months ending Dec. 31, 1916.	12 Months ending June 30, 1917.
Operation :			
Superintendence	0·013 cent.	0·013 cent.	0·010 cent.
Wages	0·043	0·042	0·047
Fuel	0·158	0·174	0·240
Lubricants	0·001	0·001	0·001
Station supplies	0·005	0·006	0·005
Maintenance :			
Station buildings	0·006	0·007	0·011
Steam equipment	0·019	0·016	0·019
Electrical „	0·003	0·003	0·001
Total	0·248 cent	0·262 cent	0·334 cent
Output, kw.-hours	125,158,800	162,117,600	210,039,700
Max. demand (30 min.), kw.	35,000	36,000	50,000
Average load, kw.	14,300	18,500	23,900
Load factor, %	40·9	51·4	47·8
Coal per kw.-hour, lbs.	1·44	1·45	1·52
B.Th.U. per kw.-hour	19,700	19,800	20,040

W. N. Y. K.

743. *The Substation Problem of the Electrochemical Plant.* **J. L. McK. Yardley.** (Am. Electrochem. Soc., Trans. 32. pp. 99–118, 1917.)—The author deals at some length with the great importance of the electrochemical engineer working in better harmony with the electrical engineer, so that the electrical equipment of substations and similar plant may be of such a character as to give the most efficient over-all working with the chemical plant. The discussion is illustrated by details of aluminium and copper plants and caustic soda installations, and allusion is made to the large voltage range which is sometimes required and the way in which this may best be met. W. R. C.

744. *Diagrams of Production and Consumption for Power Stations.* **A. Della Riccia.** (Rev. Gén. d'Él. 4. pp. 259–269, Aug. 24, and pp. 299–310,

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Aug. 31, 1918.)—In an earlier paper the author developed diagrams as follows:—(1) Annual diagram, $P = \phi(T)$, of instantaneous output power in order of decreasing magnitude (T from 0 to 8760 hrs.). (2) Annual diagram, $P_{max.} = \phi T$, of max. daily output of power, in order of decreasing magnitude (a stepped diagram, each max. power value relating to 24 hrs.). (3) A production diagram $E = \int_{P_{max.}}^{P=0} T \, . \, dp$, this being the integral curve of the first diagram. (4) A diagram showing in order of decreasing magnitude—and for the whole year—the excess of instantaneous power over the immediately lower multiple of the power of units installed. These diagrams were "monotone" functions, *i.e.* the first derivative was always of the same sign (function growing or decreasing continuously). Analogous diagrams referring to shorter periods (week or day) are here considered and shown to be useful in the solution of particular problems. Numerical examples are given and empirical rules are deduced. The method of obtaining the monotone diagrams is as follows:—Starting from a chronologic curve $P = f(T)$, representing instantaneous values of output during the time considered, the corresponding monotone diagram $P = \phi(T)$ may be obtained geometrically, with reference to the same axes OT (abscissæ) and OP (ordinates), by drawing a series of straight lines parallel to the axis of abscissæ and displacing the segments of these lines which are within the chronologic curve, parallel to themselves towards the axis of ordinates until the first segment touches this axis and all the successive segments touch each other. These successive translations yield a smooth curve (*non-accidenté*) which encloses the same area as the original diagram. Simple practical methods of deriving the desired monotone curves for $P = \phi(T)$ and $P_{max.} = \phi(T)$ are explained in the original. The period considered may be a single peak period or any period up to a year. For examples of these curves and their derivatives, and the manner of their evolution and interpretation, reference must be made to the original article. As a rule, the monotone diagram relating to the annual supply of a lighting and small-power network, as also the diagram relating to an urban traction system, has a concave section at each end and between these one or several convex sections, according to the exact nature of the load. By subdividing the tabular record of daily durations of power output, there may be obtained annual diagrams showing the effect of morning and evening peaks and of the valleys between peaks. One example given shows the application of monotone daily diagrams to determining the distribution of load between a hydroelectric plant supplied by part of the flow of a varying steam; a plant supplied from storage of the excess flow from the first stream; an installation of Diesel engines.

A "stereographic" representation of the power requirements of a network may be built up by cutting out the daily load curves plotted on cards of equal thickness and stacking the cards side by side. This representation may be shown on paper by the method usually employed to show levels on the map of a country. Where traction loads are concerned, there is generally shown a rhythmic variation during each week, owing to the fact that traffic is generally particularly heavy on certain days of the week. Similarly the characteristic features of other classes of load are shown clearly. There is a simple relation between the stereographic representation and the monotone diagram of power demand in the network for the same period: the surface between the "altitude curves" corresponding to powers P_1 and P_2 on the stereographic representation is equal to the difference between the abscissæ corresponding to the two ordinates P_1P_2 on the monotone diagram. Examples

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are given of monotone diagrams relating to the total consumption of a turbo-alternator or boiler, etc., as a function of its output; to the consumption of a group of identical units; and to the consumption of a group of different units. Given a diagram of production relating to any given period and a curve of coal (or steam, etc.) consumption for a group of producing units (*e.g.* turbines, boilers and so on), it is a simple matter to derive a diagram showing the consumption of the said group when producing the output concerned; the operation and results are illustrated. The consumption of turbo-alternators is considered in detail, reference being made to the number of variables involved. An example given assumes that a station of 18,000 kw. with 45 million units output in 1919 will reach 32,000 kw. and 87 million units output in 1926.

Characteristic curves of a similar nature are evolved for boilers and groups of boilers, and numerical examples are given. Special attention is paid to determining the most economical number of boilers to serve a given load; and the fuel consumption under various conditions. Useful comparisons are effected between various operating schedules. The various diagrams may be applied to determining the best size of generating units as regards economy of steam under given conditions of load, and the best arrangement of boilers as regards fuel consumption. R. E. N.

745. *Modern Development of Large Hydroelectric Power Schemes.* **C. F. Holmboe.** (Electrician, 81. pp. 142–147, June 21, 1918.)—*Summary.*—The extent to which a hydroelectric plant fulfils its expectations depends largely upon previous careful investigations of the conditions. This is particularly the case in regard to the amount of water available. The author outlines the procedure that should be adopted, and in conclusion he gives details of three cases of very cheap water-power development, namely, at Tysso, Trollhattan, and Rjukan, in Norway. L. H. W.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

746. *The Hydroelectric Railway.* **E. Belloni.** (Elettrotecnica, 5. pp. 344–346, Sept. 5, 1918.)—A navigable canal joining Milan to the River Po, and consequently to the Adriatic Sea, is now being considered by Italian authorities. In the present article the author draws attention to the fact that this canal would be so expensive both as regards construction and operation that the water transport carried on by its means will not provide sufficient support for ordinary railways to co-operate with it. The author, therefore, proposes the reduction of the scheme of a large navigable canal to a much smaller power canal energising a certain number of hydroelectric stations feeding an electric railway running along the canal. Figures and data are given, from which the economic convenience of the solution set forth by the author can be estimated. E. B.

747. *Regenerative Electric Braking on the Chicago, Milwaukee and St. Paul Railway.* **W. F. Coors.** (Gen. El. Rev. 21. pp. 412–418, June, 1918.)—A wiring diagram of the regeneration braking system is given, and the methods adopted in practice are fully described. It has been proved that an electric locomotive can control more tonnage at a safe speed on a descending grade than it can haul up the gradient. Moreover, on the regenerative system there are practically no repairs to the brake shoes.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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The article contains much information of a practical kind, derived from the working of the line: the schedule speeds have been improved, and the max. running speeds reduced. W. H. S.

748. *Electrification of Railways in Germany, Sweden, and Norway.* **P. Poschenrieder.** (Elektrot. u. Maschinenbau, 36. pp. 137–144, March 24, 1918. Extract of paper read before the Elektrot. Verein u. the Wasserwirtschaftverband der Österr. Industrie.)—Gives a brief survey, without details but with the leading features, of the present state of the electrification schemes in the countries mentioned. L. H. W.

ELECTRIC LAMPS AND LIGHTING.

749. *Efficiency of the Moore Tube.* **M. Wolfke.** (Schweiz. Elektrot. Verein, Bull. 9. pp. 129–130, June, 1918.)—An account of an investigation of the efficiency of the CO_2-filled Moore tube at various loadings. It is found that the efficiency–power curve shows a maximum at an efficiency of 4·7 watts per Hefner candle. The low efficiency is a consequence of the CO_2 filling, but the resulting light is a very close approximation to daylight in colour. J. W. T. W.

750. *Tungsten Lamps for Kinema Projectors.* **J. T. Caldwell, A. R. Dennington, J. A. Orange,** and **L. C. Porter.** (Am. Illum. Eng. Soc., Trans. 13. pp. 232–248; Disc., 248–255, June, 1918.)—The authors describe in detail the special forms of incandescent filaments used for projection of kinema pictures [Abs. 380 (1918)]. Photographs are presented, showing how, by the aid of a spherical mirror, an image is formed in the plane of the filament, thus producing a source of more nearly uniform brilliancy. The special condenser lens is illustrated, and a series of sketches, to scale, show how the distance between source and condenser has been progressively diminished so as to utilise a larger percentage of the total flux of light. The advantages of arc and glow-lamp outfits are tabulated, stress being laid on the greater ease of manipulation and the avoidance of noise and flicker with the glow-lamp. Lamps are run at a high efficiency, with a life of about 100 hours, and special provision is made for their rapid replacement in the event of a filament failing during a performance. The advantages as compared with arcs is greatest when alternating current is available; on d.c. systems it is less pronounced. It is estimated that 80 % of the theatres (about 21,000) in the United States, could use glow-lamp projectors, and that in this way a considerable saving in electric energy, and hence also coal consumption, could be made. In conclusion some data illustrating reflection of light by magnesium oxide, aluminium-bronze and mirror screens are presented. By regular cleaning of screens, the brightness of the image could, in many theatres, be increased 50 % above the average value. J. S. D.

751. *Graphical Presentation of Light Distribution.* **Gerhardt.** (Elektrot. u. Maschinenbau, 36. pp. 359–362, Aug. 11, 1918. Paper read before the Deut. Beleuchtungstechn. Gesell.)—Describes a method for showing graphically the total light-flux from a lamp in the form of a curve giving an approximate representation of the polar distribution. The flux within a cone of total apex angle α is $2\pi I_a(1 - \cos \alpha)$, where I_a is the mean intensity over the cone. Now the area of a sector of a circle of apex angle η° is $\pi R^2\eta/180$, where R is the radius of the circle. Hence if a polar diagram be

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drawn in which at an angle η given by $\eta = 90\ (1 - \cos \alpha)$ the radius vector R is given by $R = 2\sqrt{I_\alpha}$ then the area of the polar diagram is proportional to the total flux from the lamp, and the diagram exhibits the polar distribution to the extent that $\alpha/90$ approximates to $(1 - \cos \alpha)$. J. W. T. W.

752. *Diffusion of Light and its Definition.* **N. A. Halbertsma.** (Elektrot. u. Maschinenbau, 36. pp. 225–232, May 19, 1918.)—The terms "diffusion" and "diffused" are loosely employed in practice. Sometimes diffused lighting merely implies absence of glare and severe shadow-contrasts. When applied to globes it is, on the other hand, intended to convey the degree of uniformity of brightness over their surface, irrespective of the illumination; in other cases the terms are applied to convey degree of uniformity of illumination. Norden [Abs. 813 (1911)] has sought to regularise the latter conception in regard to shadow. The author now attempts to find a precise method of defining the diffusion of light by a surface, either by reflection or transmission. Light may be distributed (1) by refraction (prisms, cylindrical lenses, etc.), (2) by mirror-reflection from polished surfaces, (3) by diffused transmission through media (opal glass, frosted glass, etc.), and by diffused reflection from more or less matt surfaces. The two former are designated "regular," the two latter "diffused" distribution of light. The nature of the distribution of light, either by reflection or transmission, is indicated by the polar curve about an axis perpendicular to the diffusing surface. Crova has termed such a diagram the "indicatrix of diffusion." The diffusion has been termed orthotropic when the curve is symmetrical. For ideal diffusion according to Lambert's law the curve will be a circle ($I_\alpha = I_{max.} \cos \alpha$). The author mentions a number of other suggested definitions of diffusion. For example, it has been proposed to state the ratio between the intensity of the reflected or transmitted ray at 60° to that at the maximum. In regard to globes the ratio between the brightest and least bright areas has been suggested as an indication of uniformity of brightness. Sumpner has attempted to devise a method based on a presumed equation $I = I_{max.} \cos^n \alpha$, n being the distinguishing coefficient. The author proposes as a better indication that the diffusion-coefficient of a surface should be defined as the ratio between the distributed flux of light and the light-flux corresponding with ideal diffused distribution with the same max. candle-power; that is, $\sigma = \Phi/\pi I_{max.}$ For complete diffusion $\sigma = 1$; if there is no diffusion $\sigma = 0$. This is illustrated by a table in which the values for a large number of surfaces and optical media are given. The data are also represented in a diagram with angles as ordinates and candle-power as abscissæ. Complete diffusion yields a line crossing the axes at 45°; practical surfaces such as opal and frosted glass, etc., yield curves lying within the triangular area thus produced. J. S. D.

753. *Use of Solid Angles and Flux of Light in Lighting Problems.* **J. Teichmüller.** (Elektrot. u. Maschinenbau, 36. pp. 261–266, June 9, and pp. 277–279, June 16, 1918.)—In dealing with problems in illumination we have a choice of two formulæ, based respectively on the determination of illumination, by the inverse square law, at specified points, and its determination in terms of the flux of light divided by the area illuminated. The author seeks to show that the latter method is more useful in practice than is generally recognised. To illustrate its application he imagines a lamp to be surrounded with a suitable globe, divided into zones, by the aid of which the flux of light in each zone is readily visualised. He then proceeds to show.

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how the derived illumination can be calculated. The method is applied to several practical cases and it is shown how the average and also the maximum and minimum illumination obtained from two lamps in a given position can be estimated. It is remarked that the method is more readily applicable in open spaces than in rooms, where reflection from walls and ceilings adds materially to the illumination on the working plane.

J. S. D.

754. *Apparatus for determining Mean Spherical Candle-power.* **J. Sahulka.** (Elekt. Zeits. 89. pp. 253–255, June 27, 1918.)—The apparatus described by the author for measuring mean spherical candle-power utilises a series of small plaster-of-Paris matt surfaces, all inclined at 45° to the axis of the circle, which are spaced at intervals round the circle surrounding the lamp tested. The angular intervals are so selected that the surfaces correspond with zones of equal area; hence the summation of the diffusely reflected light is a measure of mean spherical c.p. The axis of the photometer bench passes through the centre of the circle, direct light from the lamp being screened, so that the photometer receives only light from the illuminated diffusing plates. The author illustrates the application of the apparatus to a half-watt lamp. The method has advantages over the use of mirrors—for example, the area of the luminous source is immaterial, the distance of the photometer can be adjusted at will and is not fixed and a small displacement of the lamp is of little consequence. The constant is obtained in the usual way by testing a lamp of known c.p. By blocking out half the plates the mean hemispherical c.p. can be measured; and by removing all but two symmetrically placed plates, the c.p. at any desired angle. J. S. D.

755. *Illumination and Hygiene.* **Reichenbach.** (Elektrot. u. Maschinenbau, 66. pp. 239–246; Disc., 246, May 26, 1918. Paper read before the Deutsch. Beleuchtungstechn. Gesell.)—The efforts of engineers have been devoted chiefly to improvements in the efficiency of lamps, and to diminishing the cost of light. But the problem of providing illumination that is physiologically desirable is equally important. The author discusses a series of problems that require elucidation. Originally 10 lux (approx. 1 candle-ft.) was assumed to be the minimum desirable for reading. But it is now recognised that higher values are needed. Cohn found that the number of columns of type that could be read within a given time increased substantially as the illumination was increased from 2 to 50 lux. Other investigations are quoted from which it appears that an illumination of the same order as daylight is theoretically useful; from a practical standpoint requirements are satisfied with between 80 and 100 lux. 25 lux might be regarded as the minimum. The quality of light is likewise of importance. Data on the heat produced by various illuminants are given, and it is remarked that the eye-lens absorbs infra-red radiation readily. But there appears little danger of prejudice from direct heat-radiation if lamps are well shaded. The overheating of air and production of CO_2, which latter should not exceed 2 %, are important in rooms of small size. Glare, and suggested limits of brilliancy (0·1–1 c.p. per cm.^{2}) are discussed, special reference being made to the prejudicial effect of intense lateral illumination. Ultra-violet light and the effect of light of different colours are finally mentioned. Ultra-violet light in excess is admittedly prejudicial, but it appears that little harm can arise from the amount in ordinary illuminants, if judiciously used. All these problems require fuller investigation from the physiological side. J. S. D.

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TELEGRAPHY AND TELEPHONY.

756. *Signalling and Interlocking of Keadby Deviation Railway and Bridge.* **J. B. Ball.** (Inst. Civ. Eng., Proc. 203. pp. 33–97 ; Disc. and Corres., 98–121, 1916–1917.)

757. *Radio-telephony in Japan.* **E. Yokoyama.** (Inst. Radio Eng., Proc. 6. pp. 117–140, June, 1918.)—After outlining the experiments in radio-telephony carried out in Japan since 1906, the "T.Y.K." system is cited. A newer system using, in the most favourable case, copper and aluminium electrodes about 0·2 in. (0·5 mm.) apart in rarefied air or other gas at a pressure of about 40 to 70 mm. as the discharger is then described in great detail. The influence of electrode design, gas pressure, electrode material, and other factors is considered. Means of securing steady and continued operation are given.

T. Kujirai's earlier system of radio-telephony is then described. This involves a direct-current, moderate voltage discharger having a rotating brass disc and a fixed Al point as electrodes.

A ferromagnetic frequency tripler of the 3-transformer type due to T. Kujirai is discussed and operating data for its use in conjunction with an Alexanderson radio-frequency alternator are given. AUTHOR.

758. *Fundamental Formula in Radio Transmission.* **L. Bouthillon.** (Inst. Radio Eng., Proc. 6. pp. 221–224 ; Disc., 225–228, Aug., 1918.)—For radio transmission with damped oscillations over flat and perfectly conducting ground, with the air regarded as a loss-free dielectric, the following formula giving the current at the base of the receiving antenna may be deduced theoretically :

$$I_r = 377 \frac{I_s}{R} \cdot \frac{h_1 h_2}{\lambda d} \Big/ \sqrt{1+\delta_1/\delta_2}$$

I_s is the current at the base of the transmitting antenna, R is the total resistance of the receiving antenna, d the distance apart in cm. ; $h_1 h_2$ and $\delta_1 \delta_2$ are the respective effective heights and decrements of the two antennæ. In the present paper some early experiments by Tissot are used to calculate the value of the constant of the formula, neglecting the transmission absorption term. The value deduced from the experiments is 390, which is in good agreement with the theoretical value. In the *discussion*, **O. C. Roos** pointed out that it is possible that Bouthillon has not deduced the proper form-factor, which would involve a change in the decrement of the receiving antenna. Allowing for this the value of the constant might be considerably nearer the theoretical value. He also considered the difference between the current distribution curve in the sending and receiving antennæ, making use of Stone's theoretical results. It appears that while a transmitting vertical antenna cannot vibrate at any multiples whatever of the octave of the fundamental, a receiving antenna can vibrate at the octave and all odd multiples of the octave. (*Ibid.* p. 285, Oct. 1918.) A correction by O. C. Roos. A. W.

759. *Propagation of Oscillations in Antennæ.* **H. Chireix.** (Rev. Gén. d'Él. 4. pp. 368–374, Sept. 14, 1918.)—The treatment of the flow of currents in antennæ is usually worked out for homogeneous antennæ with wavelengths corresponding to resonance. The author treats the more general

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case of the non-homogeneous antenna. The method is applied to an antenna consisting of three sections, each having different capacity and inductance per unit length. The distribution of current and voltage is first determined for one section, the second section is then supposed to be added with a fictitious length depending on the constants of the two sections, and such that the length of the first section may be considered to be increased by the fictitious length so defined. The third section is added in a like manner. In this manner the problem is reduced to that of a homogeneous antenna. The equations that are obtained are applied to a number of interesting special cases and, lastly, the case is considered of an antenna consisting of an infinite number of sections, *i.e.* one in which the constants vary gradually according to a function of the distance from the base. The particular case is calculated of an antenna in which the capacity and inductance per unit length vary according to an exponential law. A. J. M.

760. *Radio Communication with Moving Trains.* **F. H. Millener.** (Inst. Radio Eng., Proc. 6. pp. 185–216; Disc., 217–218, Aug., 1918.)—The radio-telegraphic researches carried on under the auspices of the Union Pacific Railroad are described. A radio "danger" signalling system was first worked; and while operative, did not give the extreme reliability required by such systems. A radio-controlled car is then described.

A series of experiments with arc radiophone equipment are considered. Their applications to inter-car wire telephone communication and train-to-station radiophone communication are given in detail. The necessary fixed stations are also described.

The experimental radio-telegraphic car laboratory is then described, together with the antennæ, ground, engine, and transmitter thereof.

Finally, receiving sets and a telephone-relay amplifier (intended to facilitate telegraphone or dictaphone recording of signals) are considered. AUTHOR.

761. *Resonance Measurements in Radio-telegraphy.* **L. W. Austin.** (Washington Acad. Sci., J. 8. pp. 498–500, Aug. 19, 1918.)—For purposes of rough tuning, many workers have doubtless made use of the click heard in the telephones of an oscillating audion circuit when it is brought into resonance with another circuit at proper coupling. As the resonance click has apparently not been mentioned in any of the publications on radio-frequency measurements, it seems probable that it is not generally known that this click offers by far the quickest and simplest means of making nearly all measurements depending on the determination of resonance. The accuracy is quite equal to that obtainable with sensitive thermo-elements, and greatly superior to the accuracy of the detector and telephone method. The following examples illustrate the procedure. (1) *Capacity of an antenna by substitution.* The antenna is loaded with inductance so as to give a wave-length of 5 to 10 times the fundamental; then the oscillating audion circuit is coupled to the antenna inductance and the audion tuning condenser varied until a click is heard in the telephones. In general, if the coupling is close, the click will be heard at different points with increasing and decreasing condenser capacity. The coupling should then be loosened until both clicks appear at the same condenser setting, or, if this is impossible, the mean setting is taken, provided the points are less than a degree apart. Next, leaving the audion condenser on the resonance point, the ground and antenna are disconnected from the antenna inductance and replaced by the

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calibrated variable substitution condenser. This last is adjusted to resonance with the audion circuit exactly as described above, and the capacity of the condenser is then equal to that of the antenna, subject to a small correction for the natural antenna inductance. (2) *Wave-length of a distant station.* The receiving antenna and secondary oscillating circuit are first tuned exactly to the distant station, preferably at loose coupling, the audion tuning condenser being adjusted to give the dead point of the beats in the case of continuous-wave reception. Next, without changing anything in the antenna or secondary, a wave-meter is coupled to the secondary and adjusted to resonance by the click method. The reading of the wave-meter gives at once the wave-length of the sending station. In a similar way, wave-meters can be compared and condensers and inductances calibrated, either by substitution or by making use of the well-known relation existing between the product of inductance and capacity and the wave-length. Besides the simplicity and quickness of this method, it has the advantage that it does away with the necessity for all auxiliary apparatus in the wave-meter, and enables measurements of the highest accuracy to be taken on shipboard, and in other places where the use of sensitive galvanometers is impossible. It should be pointed out that care must be taken regarding harmonics, in all measurements in which bulbs are used for excitation. A. W.

762. *Transfer of Telephone Exchanges.* **F. G. C. Baldwin.** (Inst. El. Eng., J. 56. pp. 390–410; Disc., 410–435, June, 1918. Abstracts in: Electrician, 80. pp. 628–630, Feb. 1, 1918. El. Rev. 82. pp. 172–174; Disc., 174–175, Feb. 22, 1918.)—This paper discusses in great detail the organisation and conduct of the work involved in transferring a large number of subscribers' lines from an old to a new exchange equipment, dealing with the matter from the preparatory stages to the final recovery of the discarded plant.

It is standard practice to effect the actual transfer of the whole of the lines at one operation. Preparatory work on the line plant may involve (*a*) teeing lines underground, (*b*) teeing lines underground and overhead, (*c*) diverting lines via the new exchange, and (*d*) if the line plant between the two exchanges is limited, the arrangement of this plant so that it serves, after the transfer, for lines from the area on the far side of the old exchange. The advantages and disadvantages of each method are discussed. The transfer from a magneto to a central battery equipment is chosen as an example and described in detail, the method recommended being the insulation of the new calling equipments at the contacts of the cut-off relays until the heat coils have been withdrawn at the old exchange.

The next section deals with the detail of the jointing and testing work involved in bringing the line plant up to the standard required on the central battery equipment and in shunting the lines into the new exchange. Drawings of the methods of making the tee connections on underground and overhead lines or in the new exchange are given. The preparatory work at the subscribers' stations is described, different methods of arranging for the change in electrical operation of the instruments being detailed. The protracted operations involved in making the preparations at the old and new exchanges and the final tests and examinations to ensure that every circuit on the new plant is ready and in order are dealt with, including the provision of special telephone facilities for the control of the transfer operation and the rehearsal on the evening prior to the transfer.

After a description of the transfer itself, traffic and operating matters are

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considered, so far as they affect it or are affected by it, and finally the post-transfer work of recovering the discarded plant and making the permanent arrangement of the line plant is described. The paper concludes with a section dealing with the organisation of the work, which includes a date schedule and a list of headings for a programme of operations.

The lengthy discussions centred chiefly around the choice of schemes for dealing with the line plant (*a* to *d* above). The use of insulating separators in the cut-off relay contacts was criticised, wooden wedges or metal clips acting on the armatures being preferred. A method of making use of the condenser in the new instrument when transferring from magneto to central battery or automatic was described. W. H. G.

763. *Wave-length and Attenuation Constants of Telephone Circuits.* **J. B. Pomey.** (Rev. Gén. d'El. 4. p. 72, July 20, and pp. 251–253, Aug. 24, 1918.)—In the first article the author discusses the case in which the resistance and leakance are small compared respectively with the inductance and capacitance. He states that the formula given by Breisig (*Theoretische Telegraphie*, p. 305) is incorrect, and proceeds to derive an exact expression in a similar form, namely :

$$\beta^2=\left(\frac{A}{2}\sqrt{\frac{L}{C}}+\frac{R}{2}\sqrt{\frac{C}{L}}\right)^2(1+\Delta,$$

but where Δ is given by—

$$\Delta=-\frac{1}{4\omega^2}\left(\frac{A}{C}-\frac{R}{L}\right)^2\left[1-\frac{1}{2\omega^2}\left(\frac{A^2}{C^2}+\frac{R^2}{L^2}\right)+\right.$$
$$\left.+\frac{1}{16\omega^4}\left(5\,\frac{A^4}{C^4}+5\,\frac{R^4}{L^4}+6\,\frac{A^2R^2}{C^2L^2}\right)+\cdots\right]$$

In the second article, the author describes a method of calculating β for the case under consideration, by means of successive approximations, due to Abraham, and then discusses in detail the steps by which he derives the above expression for Δ. He observes that the formula for β shows that the effect of the capacity and that of the inductance are strictly associated, and suggests that this indicates that it would be better to deal with questions of interference from the equations of propagation, rather than to attempt to separate electrostatic from electromagnetic induction. W. H. G.

764. *Characteristic Impedances of Loaded Lines.* **L. Schultheiss.** (Elekt. Zeits. 89. pp. 273–275, July 11, 1918.)—In determining the characteristic impedances of loaded lines it is usual to proceed as though the loading were uniformly distributed over the whole line. The author gives a method of calculating the impedance in which the "lumping" due to coil loading is considered. The method is based on a previous publication of the author's [Abs. 95 (1918)] and is not explained in detail. Briefly it consists in treating separately the two cable sections and the loading coil forming an element of the line. The results of a series of measurements are given and compared with the impedances calculated as described, and also on the assumption of uniform distribution of the loading. The error due to the lumping increases with increasing frequency of the speech current and is the lower the higher the natural frequency of the line element. In conclusion the author illustrates by an example the effect of displacing the loading coil a short distance from the centre of the section. W. H. G.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

NOVEMBER 1918.

PRIME MOVERS.

765. *Notes on Steam Meters.* **E. Claassen.** (Zeits. Vereines Deutsch. Ing. 62. pp. 521–526, Aug. 10, 1918.)—Though the mere provision of steam meters has a considerable indirect effect in securing steam economy, the meters hitherto used have conformed imperfectly to the desideratum that they should be both accurate and of rugged construction. Many types of meters yield poor accuracy, whilst others require skilled attention to keep them in order. Great numbers of St. John steam meters are used in America. The construction is very simple, the principle employed being that the lift of a cone opens a greater or smaller steam passage according to the steam flow. In order that the lift of the cone may be directly proportional to the steam flow, the generating line of the cone's surface is made slightly curved. With a right cone, double the lift permits less than twice the flow, owing to the relatively smaller free opening; on the other hand, the increased pressure-difference tends to pass more than twice the steam flow. The former factor is predominant, and to correct for it the surface of the cone is corrected by trial and error during the calibration of the meter. Calibration is therefore tedious and costly, 20 or more condensate tests often being required before sufficient accuracy can be obtained. Yet more serious is the fact that considerable errors are introduced by friction in the stuffing-box through which passes the rod connecting the cone to the recording pencil. The author gives data from his own and other tests on this matter. Mere substitution of a ground spindle effects only temporary improvement if there is opportunity for scale to deposit on the metal.

One pattern of the Claassen steam meter is shown in the original Fig., and also the special type of packing employed. The tapered, ground-in spindle has very little friction and has proved satisfactory during 6 years' practical experience. Official test data and particulars from actual installations are given in the original. The meters are standardised by the Normal Eichungskommission (Charlottenburg). A particular meter showed the following variations from the mean constant: —2·2 % at 9 mm. lift;

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+ 1·9 % at 48 mm. lift; and + 0·4% at 58·6 mm. lift; thus the error was well within the permissible limits even at ¼ the max. steam flow. A double meter used in a paper mill at Okulowka records accurately from 1000 to 11,000 kg. per hr. on one instrument, and up to 22,000 kg. per hr. when both meters are in commission.

Pressure loss in steam meters is an important factor in all except heating installations, where it is immaterial, since the energy corresponding to the pressure drop is converted to heat. The cone of the St. John meter is so heavy that it causes a pressure drop of 0·25 atmo., compared with 0·05 to 0·08 atmo. in the Claassen meter. The lower the pressure-drop in the meter, the more important it is to reduce friction in the packing to a minimum. The possibility of wilful tampering with the packing must be borne in mind; tampering with the Claassen meter is impossible. R. E. N.

766. 2500-*H.P. Rateau Marine-geared Turbines.* (Engineer, 126. pp. 36–38, July 12, 1918.)—An illustrated description of a set of standard type built by the British Westinghouse Co., Ltd., for a ship ordered by the Moss Steamship Co., Ltd. L. H. W.

767. *The Strength of Rotating Discs.* **H. Haerle.** (Engineering, 106. pp. 181–184, Aug. 9, 1918.)—The object of this article is to describe a method of ascertaining the distribution and magnitude of the stresses in a rotating disc, and which can be applied to any profile; and to provide a chart which will reduce the mathematical work evolved to a minimum and, at the same time, yield results sufficiently accurate for all practical purposes. For the tables and curves given, reference must be made to the original. L. H. W.

768. *Maintenance of Economy in the Boiler-house.* **D. Wilson.** (Electrician, 81. pp. 169–171, June 28, 1918.)—The author lays stress on the importance of keeping regular and detailed records of the performance of a power station. This is particularly important in the boiler-house. After dealing with the question of transmission of heat, the author describes the sampling and testing of coal with a view to accuracy, and lays down the routine that is desirable in regard to the control of flue gases and combustible in ashes. L. H. W.

769. *Problems of Coal Handling.* **W. B. Woodhouse.** (Electrician, 81. pp. 162–165, June 28, 1918.)—The coal pile at a power station may be regarded in the nature of an insurance. In order to arrive at the quantity that is desirable the variations in the supply and demand must be considered. Curves are given showing these variations; also data in regard to the quantities necessary for a station with a load of 100,000 kw. and the ground that would be required for sidings. In conclusion, the various types of plant available for handling coal and ashes are indicated. L. H. W.

770. *Chimney Heat-losses and their Measurement.* **M. Chopin.** (Comptes Rendus, 167. pp. 335–338, Aug. 26, 1918.)—The author describes a new type of instrument for measuring heat-losses in chimney gases, based upon the use of two electric currents, the intensity of one being dependent upon the temperature of the gases, and of the other upon the CO_2 contents of the same. The relation between the current intensity and the CO_2 contents of the gases is obtained by measuring the electrical resistance of a solution of caustic

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soda of known strength and volume with which a definite volume of the chimney gases is agitated. The absorption of CO_2 by the caustic soda and formation of sodium carbonate causes an increase in the electrical resistance, and therefore a diminution in the current that can be passed through the solution with a constant e.m.f.; for the conductivity of sodium carbonate solutions is only one-third that of caustic soda solutions. The temperature of the gases is obtained by a thermo-couple, and the indicators of the results of the two measurements are so arranged that (1) the percentage of CO_2, (2) the temperature of the gases, and (3) the loss of heat-units, can all be read off on one and the same dial. An illustration of the apparatus is given.

J. B. C. K.

771. *Effects of Moisture on the Spontaneous Heating of Stored Coal.* **S. H. Katz and H. C. Porter.** (Bureau of Mines, Dept. of Int. Techn. Paper, 172. [25 pp.], Washington, 1917.)—The only recommendation of practical import to be made as a result of the matters considered in this paper is to prevent the segregation of the fine coal in building a pile for storage. This has been proposed before as a means of reducing the danger of spontaneous combustion. The consideration of moisture now gives it further support.

L. H. W.

772. *Some Characteristics of American Coals in By-product Coking Practice.* **F. W. Sperr.** (Frank. Inst., J. 186. pp. 133–168, Aug., 1918.)—The present tendency in America is to use less of the expensive semi-bituminous coals—Pocahontas, Somerset, etc.—and to coke mixtures containing much larger percentages of bituminous coals, the volatile matter in such mixtures being from 30 to 35 %. The percentage of low-volatile coal runs in usual practice from 15 to 30 %. Very fortunately it happens that not only do such high volatile mixtures produce larger recoveries of by-products, but the coke itself is usually found to give better results in the blast-furnace, the decrease in coke consumption per ton of pig iron being in several cases quite marked. H. A. Kuhn estimated that in 1912, 75 to 80 % of all the iron production of the United States was located tributary to the coking coal of the Pittsburg district.

The geological age of a coal is no criterion as to its coking quality. As good by-product yields are obtained, and also as good coke from the comparatively recent coals of Colorado as from the early carboniferous strata of Pennsylvania. The phenomena of prime importance seem to be those of deoxidation, rather than that of devolatilisation. The highly oxygenated coals of Illinois may have less volatile matter than coal from a portion of the Pittsburg seam, and yet produce a much inferior coke. In fact the best basis for differentiation, with respect to coking quality, seems to have close relation to high or low oxygen-content and not to percentage of volatile matter; for even in the Pittsburg seam the percentage of volatile matter drops gradually from about 37 % in the western portion to about 27 % in portions of the Connellsville basin.

The Elkhorn (Eastern Kentucky) coal, the development of which in the last few years has been one of the most prominent events in the U.S. coal industry, appears to occupy a position midway between the eastern high-volatile coals and the more highly oxygenated coals of Illinois and Indiana.

J. B. C. K.

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PROPERTIES OF ENGINEERING MATERIALS.

773. *Notes on Babbitt and Babbitted Bearings.* **J. L. Jones.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1395–1401, Aug., 1918.)—Gives results of experiments carried out at the works of the Westinghouse Electric and Manufacturing Co. on lead-base and tin-base Babbitt metals.

Brinell hardness numbers at progressively increasing temperatures are given which indicate that lead-base alloys containing Pb78, Sb14, Sn8 show greater resistance to deformation than tin-base alloys containing Sn90, Sb8, Cu2, at the working temperature of bearings.

Under compressive loading the lead-base alloys used showed less average compression than the tin-base metal. Compression did not materially increase the hardness of the metals.

A tool for giving smoother and more accurate surfaces to bearings than has hitherto been usual is described. C. O. B.

774. *Thermal Expansion of Alpha and Beta Brass.* **P. D. Merica** and **L. W. Schad.** (Bureau of Standards, Bull. 14. pp. 571–598 [Sci. Papers, No. 321], 1918.)—Measurements of the thermal expansion of alpha and of beta brass in compositions such as Muntz metal, naval brass, etc., which normally are in equilibrium are given. Fundamental variations in behaviour as regards thermal expansion at temperatures up to 600° C. were noted, due to the transformation in the beta constituent.

Manufacturers of brass never quench 60 : 40 brasses, and data are given which show the ill effects of quenching. It is found that naval brass and manganese bronze which are quenched in such a manner as to leave the beta grains surrounded by alpha envelopes, are both brittle and weak and the fracture intercrystalline, and this has been ascribed to the alpha envelope. It is pointed out that alpha brass is weaker but not more ductile than beta, and the authors suggest as an explanation of the brittleness of quenched brasses, the existence of tangential tensional stresses in the beta grains immediately adjacent to the alpha envelope. C. O. B.

775. *Action of reducing Gases on Solid Copper.* **N. B. Pilling.** (Frank. Inst., J. 186. pp. 873–874, Sept., 1918. Am. Inst. Mining Eng., Bull. No. 412. pp. 1567–1589, Oct., 1918.)—It is well known that copper containing disseminated oxide, after heating in contact with reducing gases, becomes weak and friable. In the case of hydrogen the first mechanical effects of the deterioration appear between 400° and 500° C., and at temperatures above 700° the action is very rapid. Deoxidation alone cannot account for this deterioration, and it is pointed out that if steam formed by the reaction is less soluble in solid copper than hydrogen is, then it will be left within the voids formed at some considerable pressure. The combination of this pressure with the intercrystalline weakness of copper at high temperatures would force the individual grains apart. Microscopic examination of copper after this treatment disclosed intercrystalline fractures.

Measurements were made on the relative diffusion of gases with the following results; hydrogen being taken as 1000: Steam, 65; CO, 17; CO_2, 0·6.

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The distribution of oxide particles in copper is a more important factor than their total quantity. In wrought copper the particles are uniformly dispersed throughout the grains, whereas in cast copper the oxide is segregated as a eutectic at the grain boundaries and such copper is therefore extremely susceptible to hydrogenation. C. O. B.

776. *Explosibility of Coal-dust–Air Mixtures.* **J. K. Clement** and **J. N. Lawrence.** (Bureau of Mines, Techn. Paper 141. [85 pp.], Washington, 1917.)—Investigations carried out in the experimental mine having shown that dusts of too low an inflammability to be ignited in the laboratory apparatus [described in Bull. 50 and 102, see Abs. 36 (1914)] might yet propagate violent explosions in the mine, the laboratory apparatus was made more sensitive. The explosion vessel was a glass globe, 1·4 litres in capacity, fitted with a lower and an upper tubulure, in the centre of which the ignition tube was held horizontally. The tube consists of hardened "lavite," wound with Pt-wire and enclosed in a Pt-tube (0·1 mm. thick), from which it is insulated by alundum cement; the tube is held by two Pt-wires, 0·4 mm. in diam., which are fused to the ends of the coil. The Pt-Rh wire of the thermo-couple is attached to the middle of the ignition tube, the Pt-wire to a point 3 mm. to one side of the middle. Through the bottom tubulure a puff of the coal-dust to be tested is blown against the hot tube by admitting compressed oxygen; the funnel through which the dust enters is closed by copper gauze, and the dust is previously air-dried and sorted by being passed through a sieve of 200 meshes to the inch. The inflammability is estimated from the gas pressure generated by the explosion. With samples of 100 or 300 mgm. of coal-dust and tube temperatures of 1200° C. maximum the pressures (measured by the indicator of a Crosby engine) hardly exceeded 20 lbs. per sq. in. At that temperature, if not before, all the curves (pressure against temperature) became horizontal. At 750° only one sample, a lignite, gave a measurable pressure (about 1·4 lbs.); at 1200° this same lignite indicated a pressure of 17 lbs., but this sample was air-dried and contained 8·6 % of moisture against 38·5 % as received, and lignites are not of high inflammability. The order of inflammability found by these laboratory tests agreed with that found in mine experiments; the laboratory method was therefore standardised. In doing this dusts are classified as (1) dusts which, when suspended in the air, may be ignited by a flame and propagate an explosion; (2) dusts which are not ignited by a blown-out shot of black powder, by burning gas, or an electric arc, but may propagate an explosion set up in more inflammable dust or in an explosive gas mixture; (3) dusts which will not propagate an explosion. The "ignition-limit" designates the highest percentage of shale-dust with which a given coal-dust can be mixed and yet be ignited and cause an explosion; the "propagation-limit" is the highest percentage of shale-dust with which the coal-dust can be mixed and still be capable of propagating an explosion. In laboratory and mine experiments, conducted in air containing 0, 1, 2 (sometimes 3) per cent. of natural gas, the propagation-limits deduced by the two methods were found to be in satisfactory agreement, the ignition-limits less so. From experiments made with 600 coals it is concluded that the laboratory method may, on the whole, be relied upon. The fineness of the dust is, however, of great influence. Dust containing 90 % of 200-mesh particles will require 4 times its own weight of shale dust to prevent propagation; with 40 % of these fine particles 8 times as much shale-dust is required; with 20 % only twice as much shale-dust. As, however, the laboratory tests

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are made with fine dust (200-mesh) and air-dried, the errors of the laboratory method are on the safe side. H. B.

777. *Economics of Pole Timber.* **E. F. Hartman.** (El. World, 72. pp. 590–591, Sept. 28, 1918.)—The life of poles may be practically doubled by proper treatment with preservative and decay may be arrested even when decomposition is far advanced. At present only about 25 % of the poles in the U.S.A. receive preservative treatment before erection. Each year millions of otherwise serviceable poles are renewed solely owing to decay at the ground-level. If poles are sound at the ground-line soil should be removed to a depth of 2 ft. and after cleaning the wood and allowing it to dry three coats of hot Protexol (*Avenarius carbolineum*) should be brushed or sprayed on. Where slight decay has occurred, all damaged wood should be shaved away to a depth of 2 or 3 ft., using a chisel where required. If decay has extended beyond the sap wood a plumber's torch may be used to kill the organisms of decay. A wire brush should be used on the cleaned surface and three heavy coats of preservative applied as before, at least 2 ft. above and below ground-level. Filling in is then completed with small stone or fresh ground, not sand or contaminated soil. Shortening and resetting the pole is sometimes practicable. Contaminated soil may be sterilised with preservative, or crude oil may be mixed with the soil to secure a waterproof jacket for the pole. The author condemns the practice of boring holes in the pole and filling these with preservative. Where decay is far advanced, stub poles or iron bridge-pieces with concrete surrounds may be employed. In either case the pole should be cleaned and treated as above before being reinforced. A supplementary spraying with preservative at intervals not exceeding 5 years checks fungus attack in seasoning cracks. Anything from 5 to 10 years may be added to the life of a pole by arresting its decay in the above manner. The pole bill may be halved, apart from the effect of reduced consumption in keeping down the market price of new poles. R. E. N.

778. *Lignite.* (El. Times, 54. p. 33, July 11, 1918.)—From the poorest quality of lignite coal in Canada, the Honorary Council for Scientific and Industrial Research intends to manufacture carbonised lignite briquettes. A plant costing approximately $400,000 will be constructed at once near Estevan, Saskatchewan. The proposal is to take two tons of the poorest lignite in the world, having about 32 % of moisture and 7800 B.Th.U. per lb., and turn them into one ton of briquettes having 5 % moisture and 12,000 B.Th.U. Sulphite liquor will be used as the binder; it is smokeless and odourless. This liquor is the waste product from the Canadian pulp mills. Its use will result in the production of what the United States Government in its tests has demonstrated to be at least the equal of anthracite in burning quality. The Research Council has stated that this is not a laboratory experiment nor even a super-laboratory experiment, as the work has been done. Briquettes to the extent of a number of carloads have been manufactured from the identical lignites that will be used. The present undertaking is for the purpose of demonstrating the commercial feasibility of the project in a full-size plant; to test the commercial success of selling the product in the open market and through the present channels. L. H. W.

779. *Composition of Silica Bricks from Martin-furnace Arches.* **E. Rengade.** (Comptes Rendus, 166. pp. 779–781, May 13, 1918.)—Even high percentages of iron oxide do not appear to lower the melting-point of the

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bricks materially. **H. le Chatelier** and **B. Bogitch.** (*Ibid.* pp. 764–769, May 18, 1918.)—The authors give reasons why bricks impregnated with iron are unstable in equilibrium. H. B.

780. *Iron Oxide and Lime as Agglomerants for Silica-brick Making.* **Bied.** (Comptes Rendus, 166. pp. 776–778, May 18, 1918.)—Experimenting in 1916 the author found that noteworthy percentages of iron oxide did not sensibly lower the melting-point of silica even in the presence of lime. The experiments were made with sand, iron pyrites (roasted), hydraulic lime and also sodium silicate. A mixture of 91 parts of sand, 9 pyrites, 4 lime showed a swelling of 8·8 % after heating for 1 hour at 1500°, whilst the same mixture, in which 10 parts of sodium silicate replaced the lime, began to vitrify. The other data concern mainly swelling and hardness. It is further stated that a mixture of 100 parts of quartz, 8 pyrites, 8 hydraulic lime fused at 1725°, whilst the mixture of 100 quartz, 2 lime (without pyrites) fused at 1780°. H. B.

781. *Excess Pressure Maxima in the Phenomena of Water-hammer.* **M. Gariel.** (Rev. Gén. d'Él. 4. pp. 408–411, Sept. 21, 1918.)—The problem of water-hammer is one of the most important for hydroelectric installations, and recent theories in connection with its occurrence in force pipes have enabled records to be taken in the form of pressure diagrams. The author has made many experiments on these lines in conjunction with Camichel and Eydoux which have shown remarkable accord between observation and theory. The essential practical feature, however, to be evolved is a formula giving a simple determination of the max. pressure-rise following a given regulation. Historically this evaluation preceded the theoretical generalisation. Michaud's formula, which is the oldest, gives results which are frequently too high, and in consequence requires a correction factor. The author now shows that this empirical formula is the one which is best in accord with recent theory and practice, and only requires a supplementary expression whereby the max. water-hammer may be calculated for the majority of hydraulic plants. The results obtained agree with the theoretical conclusions of de Sparre [Abs. 869 (1917)], who shows that the max. rise in pressure is not realised during the first wave but during the third. H. H. Ho.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

782. *Electrolytic Zinc Process.* (U.S. Pats. 1,255,438 to 1,255,440. Met. and Chem. Eng. 18. pp. 549–550, May 15, 1918.)—The patents of F. Laist and J. O. Elton, of the Anaconda Copper Mining Co., concern the treatment of sulphates obtained by the lixiviation of roasted blende or other zinc ores. The iron salt used to clear the leach of As and Sb is prepared according to 1,255,436; scrap iron or iron ore is dissolved in sulphuric acid to produce a solution of 5 % of Fe, and manganese dioxide or ore is then added to oxidise the iron; the leach is precipitated with the ferric salts, the Fe, As, Sb being removed, and the Mn in the bath is electrolytically reoxidised. The ferric precipitate, which may include zinc sulphite, may be added to the unroasted blende, and be roasted dead (when sulphuric acid would be wasted). It is preferable (1,255,438) to roast the precipitate separately in a furnace below 625° C. Or the precipitate together with all the residues (Cu, Pb, Ag, Au and some zinc) is mixed with fine coal and smelted in a reverberatory furnace; the products are a slag of little value, fumes (collected in bags and lixiviated together with the roasted ore), and a matte (1,255,440). In the purification of the electrolyte (1,255,434) the bulks of Cu, Cd and other electro-negative metals are first precipitated with zinc dust, and the clear solution is then sent through a pair of tube mills, the first charged with zinc balls, the second with zinc shot; the purification is thus hastened and the use of zinc dust diminished (1,255,434). The remaining traces of Cu and Cd are removed by means of spongy zinc, prepared (1,255,435) from the cold, neutral, impure sulphate with anodes of zinc and currents of 2 to 80 amps./cm.^{2} at 0·5 to 2·8 volts; the sponge is dried, oxidation being prevented. For the final zinc electrolysis a bath containing 4·5 % of acid at 35° C., 8 to 5 volts and current density of 0·0215 to 0·0888 amp./cm.^{2} are recommended (1,255,439). The nature of the kathode is important; it should be an electropositive metal; Al itself is quite suitable; Al with 5 % and even 1 or 2 % of Cu will sometimes not take a deposit, especially after having been stripped several times, unless cleaned with nitric acid. The kathode should be of a pure metal also to avoid local circuits and redissolution of the already precipitated zinc (1,255,433). As the influences of small impurities persist for days even after a feed with pure electrolyte has been re-established, an indicator is finally (1,255,437) arranged in parallel to the main bath for watching the electrolysis. H. B.

783. *Effect of Oxygen upon the Precipitation of Metals from Cyanide Solutions.* **T. B. Crowe.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1279–1282, Aug., 1918.)—Much has been written on the subject of the precipitation of metals from cyanide solution by zinc, and it is stated that many factors influence precipitation, such as zinc surface, purity of zinc, percentage of lead, temperature of solutions, strength of solutions in cyanide or alkali, etc. Little is heard, however, of the part that oxygen plays in precipitation. A few years ago, while making some experiments on the effect of pressure upon the

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dissolving rate of gold from ores, the author made some bottle-tests under vacuum. The results were surprising, and showed that under vacuum practically no gold dissolved. This led him to investigate the amount of dissolved air carried by solutions at atmospheric pressure. The experiment consisted in partly filling an acid bottle with mill-solution, and connecting it by a rubber-hose to a vacuum-pump. When the vacuum was suddenly applied, a cloud composed of thousands of small air-bubbles rose out of the solution, showing qualitatively the amount of dissolved air that was contained in the solution, and also proving that the relief of atmospheric pressure on the solution permitted this dissolved air to escape.

In the early days of zinc-dust precipitation, the dust was sprinkled over the top of a tank of solution while under agitation; large quantities of zinc were used and the solution tailing was far from what was desired. Later Merrill's improved method came out. This method was a big improvement over the old scheme, allowing a material reduction in the quantity of zinc used, with much lower barren solutions, and showed very plainly the effect of oxygen in former work. Laboratory tests on the application of a vacuum to solutions before the addition of zinc dust confirmed the author's theory. Large tests were tried, apparatus was designed that would continuously apply a vacuum to solution during its flow to the precipitation presses, and gradually the vacuum system of precipitation worked its way into the mills. A further advantage of the vacuum system is that perfect precipitation can be maintained without the addition of lump cyanide, and a mill can be run with the highest strength of solution in the agitators, and not in the barren tank. Consequently the solution strength in all parts of the mill is lower, and the consumption of cyanide per ton of ore treated is nearly cut in half. The following table illustrates the saving of cyanide at the mill of the Portland Gold Mining Co., Colorado, by use of the vacuum system.

	Tons of Solution Precipitated.	Pounds NaCN per Ton Ore.	Pounds Zn per Ton Ore.	Pounds Zn per Ton Solution.
12 months, Year 1915	503,819	0·331	0·407	0·174
12 months, Year 1916	536,455	0·320	0·369	0·150
6 months, Year 1917	249,988	0·175	0 191	0·084

Years 1915 and 1916, ordinary zinc-dust precipitation. Year 1917, vacuum precipitation. J. B. C. K.

784. *Present Status of Brass Melting.* **H. M. St. John.** (El. World, 71. pp. 1129–1131, June 1, and pp. 1216–1218, June 8, 1918.)—It is pointed out that if all the brass and bronze produced in the United States were to be melted in electric furnaces the annual consumption of electrical energy for this purpose would be in the neighbourhood of 200 million kw.-hours. Certain difficulties, however, have been experienced. So far as yellow brass is concerned it cannot be said that an entirely satisfactory furnace has yet been produced. There are, of course, certain advantages in electrical methods, but no electric furnace can be expected to succeed in this field unless its use results in a saving of metal as compared with fuel-fired practice. First consideration must always be given to the metallurgical requirements, and in this

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connection the more volatile constituents of certain copper alloys introduce a difficulty. So long as the metal is contained in a tightly closed furnace chamber, which is practicable in the electric furnace, the tendency to volatilise may be stopped by the resulting vapour pressure. It is necessary, however, that the heating should be reasonably uniform; otherwise certain portions will tend to lose zinc at a higher rate than others, and if the lack of uniformity is very great the loss which occurs after the furnace is opened and during pouring will be excessive. Among the various furnaces which have been used, reference is first made to the Hering furnace, which depends upon the pinch effect. With this type of furnace there is the advantage of heating in the metal itself, but owing to the massive metallic electrodes that are necessary with considerable water-cooling, the thermal efficiency is much lower than it would be otherwise, and considerable difficulty has been experienced in constructing satisfactory transformers for use with the extremely low voltages and high currents required. So far it has not been found practicable to use this furnace with alloys high in lead because the lead has a tendency to penetrate minute cracks in the lining of the resistor channels, causing short-circuits. The induction furnace also has the advantage of internal heating, but it is lacking in flexibility in changing from one alloy to another, and the length and cross-section of a channel which is suitable for one alloy is not necessarily suitable for another. Arc furnaces suffer from the disadvantage that local high temperatures occur where the arc strikes the metal and, therefore, no furnace of this type has ever succeeded in satisfactorily melting yellow brass or other copper alloys containing an appreciable percentage of zinc. Indirect arc furnaces, where the arc plays between two or more electrodes and does not enter the metal, are more suitable. They may be used economically with alloys containing 5 to 10 % of zinc, and possibly 5 to 20 %. Such furnaces are more complicated and their thermal efficiency is not so high. Several indirect arc furnaces are now in use for melting copper alloys containing small percentages of zinc, and in a new type of indirect arc furnace the metal, as soon as it becomes molten, is agitated by rocking the furnace mechanically so as to avoid overheating of the surface layer. Nevertheless, overheating does occur and is too severe to permit the use of such a furnace for melting yellow brass. Indirect resistance furnaces may be classed into (1) those which radiate heat direct to the metal, (2) those which radiate heat to the furnace roof and thence by reflection to the metal, and (3) those which deliver heat to the metal by conduction through a refractory wall. Heating by direct radiation is the most desirable, but for this purpose it is necessary to support the resistor above the bath in some manner, and this has never been done successfully in furnaces of any size. Indirect radiation necessitates a resistor element which must be much hotter than the roof of the furnace and the roof in turn must be much hotter than the metal. Consequently the resistor must be capable of operating at a high temperature, and the heat storage of the furnace is necessarily large, so that the temperature of the metal will continue to increase after the power has been cut off. The furnace is obviously not so efficient thermally. A type of furnace has been used in which there is a combination of arcs and resistor elements, all radiating heat to the furnace roof. Certain difficulties have been experienced which have so far postponed the commercial use of this furnace. Finally, it is possible to melt brass in a crucible by means of resistor elements which surround, but do not touch, the crucible. Perhaps the most perfect results from a metallurgical standpoint can be obtained in this way, but the thermal efficiency is very low. W. R. C.

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785. *Electric Furnaces for Melting Alloys.* **W. H. Easton.** (El. World, 72. pp. 295–297, Aug. 17, 1918.)—An automatically regulated, 2-ton furnace of the Heroult arc type is used by the Driver Harris Co. (N.J.) in the preparation of nichrome and nickel steel. The charge consists of the various metallic constituents fed into the furnace in a solid state without preheating. The power taken is small at first but increases rapidly as the electrodes become hot and the charge consolidated. Subsequently the *average* power consumption is held nearly constant by the automatic regulator, but the actual power consumption fluctuates widely and rapidly owing to short-circuits established between electrodes by the charge. The power curve is more irregular with nickel-steel alloy than with the softer nichrome. The temperature of the furnace averages about 2200° F.

Energy is supplied from 2-phase, 60-cycle, 2200-volt main through a disconnecting switch and oil circuit-breaker. The latter may be operated manually and has low-voltage and overload releases. The overload release has an inverse time element. Two 400-kv.a., 2200/110-volt oil-immersed transformers are T-connected to yield 3-phase current for the furnace. The severe momentary overloads do not produce excessive heating, but tend to force the coils apart; hence bracing is used which is capable of withstanding 1500 % overload. The reactance of the transformers is double that of power transformers of equal size, and for this reason and because of the reactance of the l.t. leads, the current flowing through the furnace is not more than 5 or 6 times normal, even on short-circuit. The no-load–full load regulation is 106–100 volts and the power factor 85–90 %. A Thury regulator maintains approximately constant current at the electrodes and improves the quality of product whilst reducing time, labour, and energy expenditure. Each furnace electrode has a separate regulating mechanism and a 2-h.p., totally enclosed motor for raising and lowering. D.C. motors are used for this purpose and manual as well as automatic control is arranged. A well-equipped instrument board is provided alongside the regulators. The whole furnace is tilted bodily for pouring, by an 11-h.p., a.c. slip-ring motor located in the furnace pit and hand controlled. R. E. N.

786. *New Principle for Lightning Arresters.* **E. O. Schweitzer.** (El. World, 72. pp. 52–54, July 13, 1918. El. Rev. 83. pp. 257–258, Sept. 13, 1918.)—A long-sustained high-voltage surge or a series of frequently repeated surges may heat an electrolytic arrester to such an extent that the electrolyte dissolves the film on which the action of the arrester depends. To protect against this risk, the author has devised an electro-thermal valve which opens and closes (or varies the resistance of) the arrester circuit whenever there is danger of the arrester being damaged. Referring to the Fig., a cylindrical chamber 5 of bakelite is closed at each end by a cast-iron cap. The upper cap carries an adjustable inverted pyramidal electrode of artificial graphite; also a small relief valve 8. The lower cap carries a fixed graphite electrode 6 and a pipe which communicates with a reservoir serving to maintain a suitable pressure within the chamber. Heat developed in the electrolyte (as a result of power discharge following a lightning discharge) causes a rise of pressure in the chamber 5. The needle valve 8 relieves the pressure if the current (and therefore the heating) be moderate, but if the pressure rise be rapid the relief valve 8 cannot keep pace with it, and the level of the electrolyte falls. Heating of the electrolyte reduces its resistance; hence the current increases rapidly for a moment. Then, however, the decreasing area of contact between the electrolyte and the upper electrode comes into

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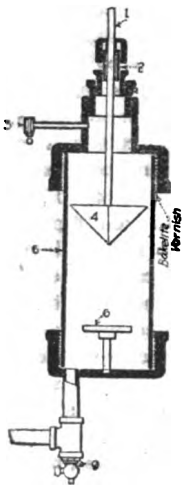
play and the current decreases rapidly but smoothly. Finally the circuit is broken by the electrolyte falling below the level of the upper electrode. The relief valve permits the electrolyte to flow back again gradually from the reservoir, and the above action is repeated if the circuit conditions have not become normal in the meantime. The higher the impressed voltage the more rapid the action of the valve. Curves given in the original show the operation of the valve when subjected to 220, 600, 1050, and 2200 volts



directly across the electrodes without limiting resistance of any kind: these show clearly the initial rise in current and the subsequent rapid make-and-break action. Further tests are being undertaken with a view to obtaining data on which to design a valve for heavier current and higher voltage. Hitherto a layer of transil oil has been used in the electrolyte chamber to reduce the risk of an arc igniting the mixture of H and O_2 formed by electrolysis, but it is probable that the oil is not required.

Although originally intended for use in series with an Al arrester to protect the latter, the electro-thermal valve is equally suitable for use alone. Connected in series with a horn-gap between line and ground, it will interrupt the flow of power current within 5 secs. from the formation of an arc at the gap. R. E. N.

787. *Three-phase Meter; determining Magnetising Current.* **P. Bourguignon.** (Rev. Gén. d'Él. 4. pp. 214–217, Aug. 17, 1918.)—The author uses two single-phase meters to measure the 3-phase consumption of a consumer on the "two-wattmeter" principle. The method is reliable and permits the subscriber's power factor to be determined easily; the essential feature is the use of independent integrating mechanisms for the two meters. The type of meter hitherto used for measuring most loads consists of two wattmeter elements operating on a single moving system and connected to the mains through series and potential transformers. The actions on the disc common to the two-wattmeter systems are very unequal when the power factor falls below a certain value, and there arises from this the possibility of serious error. However carefully the meter be maintained, there is con-

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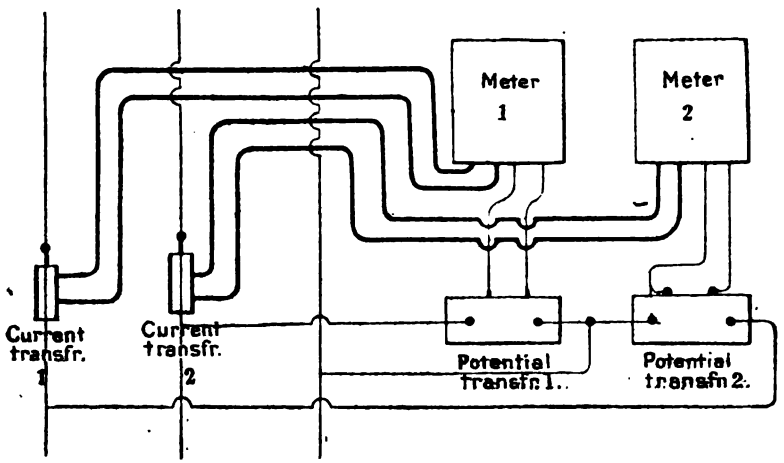
siderable risk of deterioration or open circuit in the meter transformers. If the defect is in the transformers feeding that wattmeter system which yields max effect, the trouble is detected immediately by the sudden fall in the consumption recorded (which decreases to from 25 % to 10 % or less, according to the power factor). If however, it be the minimum wattmeter system which is effected, the defect may escape detection for some time since the decrease is only 10 or 20 % and may be masked entirely by an increase in the actual amount of energy delivered. A completely duplicated meter equipment would safeguard against such mishaps, but it is not sufficient to run two meters from one set of transformers. The cost and encumbrance of completely duplicated meters is rarely incurred in any but the most important installations.

By using two single-phase meters connected to independent transformers (see Fig.) the following advantages are secured : (1) A defect in either meter system is disclosed by the meter concerned ceasing to register ; (2) the power factor of the load is determined easily and accurately so that it is



possible to enforce, without difficulty, a tariff based on the power factor. If the meter readings over a certain period be C_1, C_2, the total energy supplied during that period is $(C_1 + C_2)$ and the mean power factor is given by $\tan\phi = \sqrt{3}(C_1 - C_2)/(C_1 + C_2) = \sqrt{3}[1 - (C_2/C_1)]/[1 + (C_2/C_1)]$. Values of $\tan\phi$ $\cos\phi$, and ϕ are given for values of C_2/C_1 advancing by tenths from $-0{\cdot}15$ to $+1{\cdot}0$. If preferred, for tariff purposes, the magnetising energy $\int\sqrt{3}UI \cdot \sin\phi \cdot dt\,(= \sqrt{3}(C_1 - C_2))$ may be deduced, instead of $\cos\phi$, from the meter readings.

Generally the meter C_2 runs positively, *i.e.* in the direction of increasing indications, but in some cases (including loads of low power-factor and particularly cases of plant running light) it may happen that the meter C_2 runs temporarily in the reverse direction. This necessitates the use of meters of high mechanical sensitivity ; friction correction would involve asymmetric running and the necessity for it is therefore to be avoided. The rational combination of meters described offers obvious advantages over single-reading meters arranged to record a complex quantity made up partly of real and partly of "wattless" energy. R. E. N.

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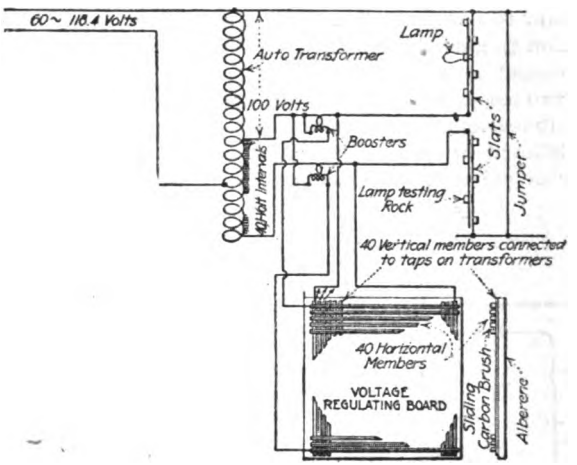
788. *Maintaining Accurate Test Voltage.* (El. World, 72. p. 206, Aug. 3, 1918.)—The arrangement illustrated in the Fig. is used to control voltage for tests on lamp-life. Accurately controlled alternator pressure of 118·4 volts, 60 cycles is fed to an auto-transformer with 40 taps intended to give 1-volt steps from 100 to 140 volts. These steps are not exactly 1 volt and their regulation (with load variations) is not exactly uniform. A small transformer is therefore introduced in each line with its secondary in series with the life-test line and the primary connected to a switchboard. To the latter are



also brought the 40 voltages. The board has vertical bars carrying the voltages 0 to 40; and horizontal bars connected to the boosting transformers. By means of carbon brushes on the horizontal bars, the small transformers may be used to add to or subtract from the line voltage anything from zero to nearly 2 volts. This fine adjustment, together with 40 voltage-steps on the secondary of the transformer, permits of very fine voltage regulation. The pressure on the life-test lines may be set to the exact values desired, and is checked each day against the 118·4-volt supply, using a two-element electro-dynamometer as a differential voltmeter. R. E. N.

789. *The Oscillating Energy in Alternating-current Circuits.* **G. Szarvady.** (Rev. Gén. d'Él. 4. pp. 411–422, Sept. 21, 1918.)—With the usual notation when we have resistance, inductance, and capacity in series in a circuit we have $e = Ri + L\,\partial i/\partial t + \int i\partial t/c$. Hence writing v for the difference of potential at the terminals of the condenser, $v = \int i\partial t/c$ and $i = c\partial v/\partial t$. Thus we get $ei = Ri^2 + \partial/\partial t\,.\,(\frac{1}{2}Li^2) + \partial/\partial t\,.\,(\frac{1}{2}cv^2)$. The last two terms give the rates at which energy is being stored in the magnetic field and in the condenser respectively. The author discusses at length the oscillation of energy taking place between the condenser and the inductive coil. When the current is sine-shaped the numerical value of the oscillating energy is found at various instants during the period. When the current is not sine-shaped, a simple method of solving the problem is indicated by means of the watt and the wattless components of the current. It is shown that Ohm's and Kirchhoff's laws apply to these components [see also Abs. 882 (1917)]. It is proved that the flux of energy in a network can be made up by the superposition of two

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distinct systems, one being the "permanent" power and the other the oscillating power. A. R.

790. *Graphical Determination of the Combined Resistance of Parallel Conductors.* **E. Haudié.** (Rev. Gén. d'Él. 4. p. 297, Aug. 31, 1918.)—Several graphical methods have recently been published [Abs. 340 (1918)] for determining the combined resistance of parallel conductors. The one now described has the advantage that the final result is obtained by successive consideration of each parallel conductor, instead of by the successive repetition of the method applying to a single pair. The resistances r_1 r_2, etc., of the branches, or multiples of 10 thereof, are expressed as the tangents of a series of angles, thus, $r_1 = \tan a_1$, $r_2 = \tan a_2$, etc. Two parallel lines AM and BN are drawn at any convenient distance apart. A line Ab_1 is drawn making an angle a_1 with AM and cutting BN at b_1; b_1a_1 is drawn perpendicular to AM, meeting it at a_1; a_1b_2 is drawn at angle a_2 to a_1M, meeting BN at b_2; b_2a_2 is drawn perpendicular to AM, meeting it at a_2, and so on. When the last point b_n is obtained, the tangent of the angle b_nAM is the required value of the combined resistance. A. J. M.

791. *Change of Specific Inductive Capacity with Temperature and Impregnation in Paper.* **H. C. P. Weber** and **T. C. Mackay.** (Frank. Inst., J. 186. pp. 874–877, Sept., 1918. El. Rev. Chicago, 78. p. 525, Oct. 5, 1918.)—A description is given of experiments designed to give preliminary information of the behaviour of a number of materials. It appears that the specific inductive capacities of all the substances tried (paraffin, ceresin, montan wax, ammonium stearate, and carnauba wax), are much higher when impregnated into paper than when alone. Decided changes are shown in some cases in the neighbourhood of the melting-point, but further work would seem desirable along these lines. V. C.

792. *Some Considerations relating to Large-Power-Station Switchgear.* **H. W. Clothier.** (Electrician, 81. pp. 175–179, June 28, 1918.)—The author deals particularly with oil-switches for large powers. There are a number of controlling factors in design, such as length and velocity of break, head and volume of oil, strength of container, lag, and ventilation. These are considered, and diagrams are given illustrating the conditions found in practice. Drawings are reproduced showing a form of switchgear in successful operation and suitable for use in a power station of 60,000 kw., and the possibilities for larger power station gear on armoured lines are implied. In conclusion, emphasis is laid upon the desirability of research on the conditions to which switchgear is subject. L. H. W.

793. *The Testing of Switch and Transformer Oils.* **G. Schendell.** (Elekt. Zeits. 37. pp. 242–245, June 20, 1918.)—The author describes methods of testing commercial oils: these tests are considered to be specially necessary at the present time in Germany in consequence of the fact that raw materials, often of unsuitable kind, are used in emergencies. The tests are described in various sections under the headings: (1) The kind of oil, *i.e.* whether resinous or mineral; (2) the colour: the oil should in any case be translucent; (3) consistency; (4) mechanical impurities: the oil should contain neither straw, fibrous particles, nor sand; (5) specific gravity: transformer oils between 0·85 and 0·92: switch oils between 0·88 and 0·9; (6) viscosity: on Engler's

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viscometer transformer oils should not be above 8, and switch oils not below 10, as compared with water at 20° C. (a description of this test is given); (7) inflammability: for transformer oils, the vapour should not inflame below 160° C., and for switch oil not above 170° C., (8) the burning-point, about 20 deg. C. higher; (9) the freezing-point: in transformer oils not above −20° C., and in switch oils not below −20° C.; (10) the tendency of the oil to deposit resinous particles: this test is very important, and fully described; the oil is put in a flask and heated electrically by an external spiral to 120° C. for 70 hours; a strip of clean copper and a cotton bandage are suspended in the oil; the cotton bandage should not lose its strength and the oil should not become cloudy, but these conditions are very difficult with present commercial samples; (11) the oil should not tend to deposit tarry substances; (12) the volatility of the oil; (13) its water-content; (14) its acid-content; (15) its content of free alkali; (16) its sulphur-content; (17) its resinous content; (18) its asphalt content; (19) its content of oils of an inadmissible character; mixtures of mineral and resinous oils must not be used in transformers, and it is therefore in this case necessary to determine whether any such admixture is present. W. H. S.

794. *A Central Station Company's Electric Kitchen.* **A. F. Allsop.** (El. Rev. Chicago, 72. pp. 903–904, June 1, 1918.)—The Commonwealth Edison Co. has installed at its Fisk Street Station a complete electric kitchen for the use of the employees. The equipment comprises one range 17 kw., one bake oven 8·5 kw., one broiler 5 kw., one toaster 3·15 kw., one steam table 2·5 kw., three 20-in. disc stoves 2·7 kw. each, two coffee urns 2 kw., one 18 × 24-in. griddle 3 kw. The cost of this equipment was $1877, or, the total connected load being 47 kw., approximately $40 per kw. Meals are cooked on an average for between 200 and 400 men, necessitating the cooking of 600 pies, 2200 loaves of bread, and nearly 400 lbs. of meat per month. The electric equipment is on standard lines and includes a steam table, which is used to raise steam for two roast pans, three gravy pots, and six 2-gallon vegetable pots. The steam is raised from five immersion heaters of 0·5 kw. rating. The kitchen measures 19 ft. by 20 ft., and this space is sufficient to accommodate the equipment. W. E. W.

795. *Electric Welding with Covered Electrodes.* **E. G. Rigby.** (Eng. Club Phil., J. 35. pp. 472–482, Oct., 1918.)—Welds made by plain iron or carbon rods as electrodes are frequently deteriorated by pitting and oxidation, resulting in brittleness and porosity and breaking up of the metallic structure. Oxidation renders a joint peculiarly liable to corrosion, which in shipbuilding work is of the highest importance. In the covered electrode process the electrodes are surrounded by a covering of blue asbestos yarn which in fusing acts as a reducing agent, and by excluding the atmosphere from the fused metal effectually prevents oxidation of the deposited metal. The yarn is coated with silicate of Na, Al, or the like to vary the fusing temperature of the asbestos yarn. The electrode, further, has combined with it a small quantity of metal capable of exerting a strong reducing action, such as Al in the form of a fine wire incorporated in the covering. In operation the arc is formed by touching the work with the end of the electrode held vertically, after which the electrode, still in contact with the work, is dropped to an angle, when the arc is immediately destroyed, owing to the covering passing into the igneous state. The action once started, the electrode melts at a uniform rate so long as it remains in contact, and leaves a

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seam of metal perfectly diffused into the work, the covering material forming a slag which floats and spreads over the surface of the weld as it is made. Steel plates or castings can be readily cut by dipping the electrode in water and with a relatively high current applying the point of the electrode to the piece to be cut and moving it quickly up and down through the thickness of the plate, allowing the molten metal to drop.

The need for properly training welders is emphasised, as electric arc welding demands a high degree of skill and experience, especially in the case of long seams and joints met with in ship construction. Various methods of applying the process to shipbuilding and similar work are fully described and illustrated. R. J. W.-J.

796. *Electric Arc Welding in Railway Shops.* **E. Wanamaker.** (Engineering, 106. pp. 185–186, Aug. 16, 1918. Paper read before the Western (U.S.A.) Rly. Club.)—The paper demonstrates the importance in war of electric arc welding for repair work, especially in locomotive shops. A general descrip-

TABLE I

COMPARISON OF ELECTRIC WELDING *v.* OLD METHODS AND GAS WELDING

Description of Parts.	Cost, Old Method.	Cost, Gas Welding.	Cost, Electric Welding.	Saving over Old Method.	Saving over Gas.	No. of Engines
	$	$	$	$	$	
Valve stems	16·28	15·26	4·76	11·52	10·50	6
Eccentric straps	17·95	7·63	2 38	15·57	5 25	2
Cross heads	356·40	120·23	37·73	318·67	82·50	13
Piston heads	47·93	32·74	10·24	37·69	22·50	4
Frame braces.....	99·50	48·00	15·00	84·50	33·00	10
Crank arms.....	18·81	26·14	8·14	10·67	18·00	5
Engine truck equalisers	7·70	17·24	5·24	2·46	12·00	2
Truck frame	15·70	13·04	4·04	11·66	9·00	8
Wheel spokes	1276·80	113·08	35·08	1241·72	78·00	15
Main-rod blocks	15·88	28·34	6·84	7·04	19·50	9
Triple valve gauge ...	20·00	3·27	1;02	18·98	2·25	1
Link blocks	72·24	51·49	15·49	56·75	36·00	20
Plugging and building up holes	349 69	280·94	140·47	209·22	140·47	70
Smoke box	61·38	32·48	9·93	51·45	22·50	2
Hub liners	12·51	13·11	4·11	8·40	9 00	3
Strip on cross heads...	25·82	31·00	12·66	12·66	18·34	3
Boiler casings	68·21	30·30	9·82	58·89	20·92	1
Flat spots on tyres ...	99·86	95·77	29·77	70·09	66·00	4
Cylinder bushings.....	35·65	9·40	3·40	32·25	6·00	1
Buildings up side rods	93·48	81·16	31·16	62·32	50·00	2
Cracks in tanks	372·69	118·62	35·16	337·53	78·46	14
Petticoat pipes	140·52	52·87	16·87	124·15	36·00	18
Filling worn spots ...	2677·80	1064 60	329·60	2348·20	735·00	128
Pins	70·66	87·23	27·23	43·43	60·00	27

tion of the process is given, and comparisons are drawn between the electric and other methods of welding. The Rock Island Railway has adopted electric welding on an extensive scale, employing no less than 38 individual plants for this purpose, of which ten were mounted on brackets in the largest locomotive shop, the remainder being of portable type and weighing, com-

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plete with truck, about 1700 lbs. All of these units are motor-generators, having inherent regulation and an arc stabiliser. The portable unit system was found to be 30 to 40 % cheaper to install, owing to the elimination of the low-voltage distributing system. A complete organisation has been worked out, particulars of which are given, for utilising the welding equipment to its fullest extent. The author considers that the thorough training of the workers in electric arc welding should be regarded as a necessary additional course to their apprenticeship. Tables I and II in the original (reproduced here in part only) show the results of about 6 months' operation of the complete system.

The figures given in a summary of Cost and Savings show that the saving effected by the electric arc-welding system is at the rate of approximately $200,000 per annum. This includes a direct saving, as compared with other methods, of about $186,000, the balance being made up by the saving arising

TABLE II

COMPARISON OF ELECTRIC WELDING *v.* OTHER METHODS. PARTS THAT CANNOT BE WELDED BY GAS.

Description of Parts.	Cost of Other Methods.	Cost of Electric Weld.	Saving.	No. of Engines.
	$	$	$	
Pedestals	645·00	45·24	599 76	5
Tank frames	9·08	1·36	7 67	1
Shop tools	34·36	3·40	30·96	4
Piston rods	78·64	16·37	62·27	10
Sharp flange drivers	165 40	20·28	145·12	—
Truck side	194·00	10 20	183·80	4
Building up driver axles	121·50	4·90	116·60	1
Steel car underframe	11·34	1·71	9 63	1
Building up car axles	315·00	25·24	289·76	—
Bushing staybolt holes	294 96	73·74	221·22	26
Welding flues	2607·65	521·53	2086·12	102
Frames	931·00	133·28	797·72	11
Cracks in fire-boxes	2481·27	297·17	2184·10	92
Total	7839·15	1154·42	6684·73	—

from the increased engine-running days, amounting to some 1400 per year. By the operation of the electric welding system the service of four additional engines, worth $200,000, has been obtained without extra cost. The welding installation cost about $40,000, and the running costs are approx. $34,000 per ann. Taking the value of the engine at $40 per day, the additional service will pay for the entire running cost of the welding plant, and leave a surplus of $22,000, in addition to which savings were made in the repair of engine parts amounting to twice the sum saved by the additional service obtained. The author estimates the net return on the investment in electric welding plant at 500 % per annum. The application of the process to the maintenance of freight and passenger cars promises to eclipse in importance the present results, and is likely to cause changes in many forms of construction, the welding of fire-boxes, tanks, etc., becoming an economical

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practice. The cast-steel truck side-frame will last almost indefinitely where electric welding is used in maintenance. Bolts and nuts may be welded to prevent their working loose. With a slag-coated electrode steel having a carbon content of 0·50 % can be deposited, and by this means worn or damaged flanges of driving wheels can be repaired, as well as rails and special track work. R. J. W.-J.

797. *Electric Arc Welding.* **R. E. Kinkead.** (Engineering, 106. p. 185, Aug. 16, and pp. 213–215, Aug. 23, 1918. Paper read before the Cleveland (U.S.A.) Eng. Soc., Dec., 1917.)—In autogenous welding by the electric arc and oxy-acetylene processes the metals are heated to a liquid state, poured together into a homogeneous molten mass and allowed to cool. With very few exceptions the same operations may be performed by either process, but the very great localisation of the heat in arc welding gives it a marked advantage over oxy-acetylene for welding on boiler-plate and sheet metal. The difficulties arising from expansion and contraction with the attendant buckling of the plate and cracking of the weld encountered in the use of the gas process are, to a certain extent, eliminated in the arc process. The higher temperature of the arc and the greater heat localisation enable it to do at least three times more welding with the same amount of heat than is possible with oxy-acetylene. The approximate heat quantities involved in the welding arc are expressed by the formula—

$$H = E \times 1 \times T \times 3418/1000,$$

where H = heat in B.Th.U., E = average e.m.f. across arc, I = average current in arc circuit, T = time arc is in operation in hours, and the factor 3418 = heat equivalent of 1 kw.-hr. energy in B.Th.U.

The heat liberated by the oxy-acetylene flame may be calculated, knowing that 1 cub. ft. of an oxy-acetylene mixture gives about 1550 B.Th.U.

One of the most interesting applications of arc welding is in locomotive shops, a few of the purposes for which it is used being to weld the flues into the back flue-sheet of the boiler; to weld cracks and patches in the fire-box; to weld in new sections of the flue-sheet, door-sheet, or side-sheets. Broken frames are welded in from 6 to 10 hrs. without dismantling the engine. Worn links, guides, hangers, etc., are built up with new metal, re-machined, and put into service in a few hours. Worn flanges on the driving wheels are built up without dropping the wheels and the engine is put in service without turning the tyre. R. J. W.-J.

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GENERATORS, MOTORS, AND TRANSFORMERS.

798. *The Mechanical Oscillations of Synchronous Machines.* **C. della Salda.** (Elettrotecnica, 5. pp. 342–344, Sept. 5, 1918.)—In a former article [Abs. 791 (1917)] the author has treated the problem of the mechanical oscillations of synchronous machines. Dina having criticised [Abs. 415 (1918)] the article aforesaid and the results obtained, the author in the present article demonstrates the reliability of his calculations and results. As the demonstration deals with many points of detail it does not allow of abstraction. E. B.

799. *Magnetic Pull in Electric Machines.* **E. Rosenberg.** (Am. I. E. E., Proc. 37. pp. 1069–1113, Sept., 1918.)—This question has already been dealt with in a German article bearing the same title [see Abs. 50 (1918)].

800. *Parallel-connection and Voltage Regulation of Large Rectifiers.* **B. B. Schäfer.** (Elekt. Zeits. 39. pp. 321–324, Aug. 15, 1918.)—Methods are discussed for the paralleling of large mercury-vapour rectifiers with each other and with other sources of current. By using choking coils, especially with the addition of auxiliary windings, the problem may be solved without

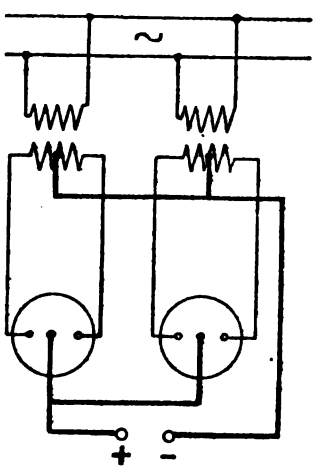

FIG. 1

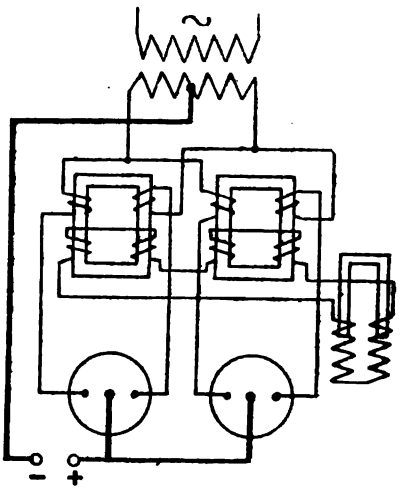

FIG. 2

affecting appreciably the efficiency and power factor. Various methods of voltage regulation are also described and very satisfactory results are claimed. It is a useful characteristic of mercury rectifiers that one or two sizes will cover a range of outputs and voltages which would involve 20 or 30 types of transformers; within commercial limits, at any rate, Hg rectifiers are unaffected by frequency. The same spacing of electrodes will serve a range of pressures from 65 to 650 volts, and there is little practical advantage in adapting the electrodes to a number of current values. The Glarus Rectifier Co. has standardised two sizes of steel-clad rectifier, for 250 amps. and 500 amps. respectively and for any rectified voltage between 110 and

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800 volts. The latest mercury rectifier installations provide up to 16,000 amps. at 250 volts, and 550 amps. at 1100 volts. Parallel operation of several rectifiers offers no special difficulty. Once the vacuum is thoroughly established, the pressure drop in the arc is nearly constant at 16 to 10 volts down to the lowest current-values. The negative nature of the pressure-current characteristic is much less pronounced than in the ordinary arc, and a small choking coil provides suitable ballast and may also be used for purposes of voltage regulation.

Unless certain special connections are to be used, the lowest voltage drop between no-load and full load is obtained by providing each rectifier with its own transformer (Fig. 1). The voltage drop of the transformer then secures uniform division of load without the use of choking coils. Compared with the provision of a single transformer of equivalent capacity, the above arrangement involves higher capacity expenditure, but provides greater security in operation. Several alternative connections are given for single-phase and polyphase rectifiers permitting the realisation of a voltage that is constant within 6 to 10 % between no-load and full load, in a group of paralleled rectifiers. Reference should be made to the original for a comparison between the various systems of connection.

As regards voltage control, the fixed ratio between the a.c. and d.c. voltages makes it necessary to alter the former in order to vary the latter. The applied a.c. voltage may be varied by altering the effective ratio of the transformer or by means of an induction regulator or a transformer with plunger core. The induction regulator system is very useful in tramway and similar service where there are frequent violent changes in load, and this system has hitherto been used almost invariably for voltage control in relatively large rectifier installations. In small installations (*e.g.* charging stations up to 10 or 20 kw.) the use of choking coils with plunger cores is quite satisfactory. Fig. 2 shows a good arrangement of this type for use where several rectifiers are paralleled. Additional windings are provided on the anode choking coils, and short-circuited through the regulating choking coil. Better regulation and a considerable improvement in power factor are obtained. Several other systems of connection and their special advantages are described in the original. A compounding arrangement is also described which makes possible the maintenance of constant voltage or yields an increase of 10 to 15 % in voltage from no-load to full load, if required (*e.g.* to compensate for drop in a long feeder).

The Hirschberg municipal electricity works has three mercury rectifiers, rated at 540 amps., 465 volts. One of these is in reserve, and the others operate alone or in parallel with a storage battery to supply the lighting and power load. Voltage regulation over a range of 10 % is obtained by an induction regulator connected on the l.t. side of the 6-phase transformer.

R. E. N.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

801. *Sag Calculation for Iron-wire Lines.* **M. D. Leslie.** (El. World, 72. pp. 196–197, Aug. 8, 1918.)—Stringing iron wire with less sag is suggested as a practical wartime economy where the usual factor of safety is not essential and weather conditions are not severe. This suggestion is based on experience gained by the Midland Water, Light, and Ice Co. when it had to obtain greater ground clearance on a certain line by stringing iron wires with 8½ ft. sag on 875-ft. spans instead of 6·9 ft. at 60° F. as originally intended.

Some companies allow for the same sag with iron as with copper wire; this is unnecessary. The Midland company uses a modulus of elasticity of 24,000,000 and a coefficient of expansion of 0·0000064 per 1 deg. F. for iron compared with 16,000,000 and 0·0000096 for hard-drawn copper. Numerical examples in the original lead to sags from ⅓ to ½ as great as those which have hitherto been considered desirable. Where weather conditions are not severe and the line runs over territory which does not demand a high factor of safety, it seems reasonable to work iron up to 75 % of its strength. Practical experience has justified these views. An experimental line was pulled practically without sag on spans of 412 ft. and withstood a temperature below zero and high winds without failure or apparent damage. Certain lines have withstood winter conditions, though they were theoretically incapable of doing so. Probably the reason why existing practice is too conservative is that the max. loading conditions are seldom, if ever, realised in practice. Flaws soon disclose their presence in tightly strung lines; but once they are remedied, subsequent service is quite satisfactory. In many cases occasional breakdowns are preferable to heavy interest charges on heavy-sag lines mounted on poles higher than otherwise required. Without going too far, it may be claimed that the less liberal line suggested is quite adequate for long lines supplying small communities. R. E. N.

802. *Steel Conductors for Series Circuits.* **L. M. Klauber.** (El. World, 71. pp. 1313–1315, June 22, 1918.)—There have been failures in steel conductors owing to corrosion and also owing to annealing after short-circuits. Still, extra-galvanised stranded steel has long been used successfully for guy ropes, and if similar steel was used as cable of a sufficient size, there is no reason to believe that its life is not reasonably long. Steel may therefore have to be used more extensively in the future owing to the price of copper, which may remain high. The skin effect must also be considered with solid conductors in order to avoid excessive drop at high current densities. The author gives a formula, which helps the designer to choose the material for the conductor: and he shows its application to a particular case, but it appears to be applicable only to the problem of street lighting on the series system. He also gives a curve showing the fluctuations in ratio between the cost of copper and steel for the past 9 years. Finally he considers the most economical size of wire to use. W. H. S.

803. *Economy in Electrical Distribution.* **W. B. Stelzner.** (El. World, 72. pp. 292–295, Aug. 17, 1918.)—It is a matter of increasing importance for

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central stations to rearrange equipment and improve construction so as to cope with increased demands whilst purchasing a minimum of new equipment. Distribution losses must be reduced to a minimum; for instance, where automatic voltage regulators are used in lighting feeders, 75 % of the iron loss may be saved by opening the primary circuits during light-load periods. Too small primary lines in a distribution system result in excessive copper loss, and in low voltage, decreased power, and loss of revenue. Changing transformer locations may reduce losses in low-voltage lines. Low power-factor at the load is a serious obstacle to economical distribution and is generally due to the use of induction motors at partial load. The author discusses the h.t. and l.t. line-copper losses, the induction regulator losses and the transformer losses under average conditions in the case of a medium-sized system comprising a generating station connected by four lines to a substation which serves 1 power and 3 lighting feeders. The feeders are equipped with single-phase regulators and supply current at 2400 volts. A synchronous converter supplies a railway load from the substation. Whereas pressure in the h.t. lines may be controlled by voltage and power-factor regulators, such apparatus is not used in the l.t. lines and regulation at the loads is therefore determined almost wholly by the l.t. line drop.

In any particular installation, knowledge of the actual losses and their distribution over the system is essential to max. economy in distribution. A survey of losses shows where extra line copper is required and where there is idle copper. In many cases the spacing of transformers so as to supply large areas permits of fewer and larger transformers being used and gives the latter the benefit of higher diversity factor in connected load. In some cases, these advantages are more than offset by losses in l.t. lines. Mistaken capital economy may impede development of the system; on the other hand, the engineer must bear in mind what would probably be the demand if the whole energy consumption of the district were supplied electrically.

R. E. N.

804. *Economic Proportion of Hydroelectric and Steam Power.* **F. G. Baum.** (Am. I. E. E., Proc. 37. pp. 1115–1119, Sept., 1918. El. Rev., Chicago, 73. pp. 450–451, Sept. 21, 1918.)—This paper describes a new method of determining, for any power system, what proportion of generation should be hydroelectric, and what steam, from the standpoint of economics. A curve is obtained showing "total cost per kilowatt-year for hydroelectric and steam power." P. E. S.

805. *Practical Limitations to Power-factor Correction.* **R. Kelly.** (El. Rev., Chicago, 73. pp. 243–244, Aug. 17, 1918.)—The author points out the difficulties and uncertainties of the problem of power-factor, which is different in the various sections of a line and at different hours of the day. Many questions are concerned with the matter, and the problem of placing a synchronous condenser to best advantage in a power-line network is not easy. It is dependent on a consideration of the various power factors in the line and their changes, also on estimates as to possible developments. A number of instances are given, which tend to show that even in specific cases much that is very debatable arises, and little can be done in the way of laying down any general solution. W. H. S.

806. *Carrying Overloads by increasing Primary Voltage.* **W. B. Stelzner.** (El. World, 72. p. 447, Sept. 7, 1918.)—Increased load can often be carried,

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without adding copper to the primary distribution lines, by raising the primary voltage. The secondary voltage is, of course, kept at its normal value, and the primary voltage must not be increased too much, or the iron loss in transformers may become serious. It is in general economical to raise the primary voltage by 10 % ; curves showing the influence of primary voltage on iron loss and exciting current are given in the original.

R. E. N.

807. *The Central Station and the Industrial Electric Heating Load.* **A. F. Allsop.** (El. Rev., Chicago, 72. pp. 979–982, June 15 ; 1029–1033, June 22, and 78. pp. 5–6, July 6, 1918.)—It is only within the last year or so that industrial heating has been taken up seriously by central stations, and it is estimated that the total load now connected is about 1,000,000 kw. This field is one of great potential importance, to small as well as to large stations. In most cases electric heating offers one or more of the following advantages : —Increased production, improved product, safer and healthier working conditions, and saving of time. The cost per thermal unit is frequently much higher for electric heating than for other systems of heating, but if the advantages of the former be capitalised, the electrical system can be shown to be quite economical. An even heat distribution is easily obtained ; uniformity of product is secured ; and space is saved in the oven or furnace equipment. A large part of the present article is devoted to enumerating possible applications for electric heating in various industries. In such work as drying plaster casts, the uniformity of electric heating permits a higher temperature and much more rapid drying than could be practised satisfactorily by other means. Examples are cited from various industries to show that the overall economy of electric heating may obviate the necessity for moving to larger premises.

From the central station point of view electric heating offers the advantage of high load factor (sometimes 100 %) and high power factor. Due to their safety and constancy, electric heaters are often used (unattended) during off-peak hours. Many industries have a seasonal peak as regards heating load, but the net effect on the whole system is to show no heating peaks. It is important that the correct apparatus be installed in every case. Standard heating units can often be applied successfully to service quite different from that for which they were designed ; a number of examples are given in the original. For equal connected kw. a number of small consumers are more valuable than one large consumer. A special list is given of applications of electric heating to munition purposes. Electric gun-heating furnaces (15 to 75 ft. long, and 3 to 7 ft. internal diam.) yield temperatures from 700° to 1000° F., and perform easily work which it is difficult to carry out in a combustion furnace. The electric furnace is built up from sections about 6 ft. long and separate heat control is provided for each section. R. E. N.

808. *Performance of Induction Motors in Conjunction with Flywheels and Slip Regulators.* **H. Vickers.** (Electrician, 81. pp. 248–250, July 19 ; 269–271, July 26 ; 293–295, Aug. 2, and pp. 313–315, Aug. 9, 1918.)—The author deals mathematically with the subject, giving numerical examples and considering the cases of continuous, intermittent, and automatic slip regulators and the Ward-Leonard system. Alternating-current motors are now used to an enormous extent to drive rolling mills and for colliery winding. In order to balance the load on the generating plant, a flywheel is fitted to the induction motor and the latter is caused to decrease in speed by introducing resistance

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in the rotor circuits. In the continuous slip system, rotor resistance is permanently in circuit; in the intermittent slip system the resistance is inserted at a predetermined value of load and its function is to keep the motor current as nearly constant as possible. When a works generates its own current it is important to use relatively heavy flywheels; but when energy is purchased from central stations the method of charging for it affects the size of flywheel which should be used. A heavy flywheel should be used where the maximum demand tariff is in force, and a light flywheel and a relatively large motor where a flat rate is in force. Where an automatic slip regulator is introduced at a predetermined load, a slip-ring motor (with stator excited from the secondary of a series transformer) is used to operate the electrodes. The rotor is controlled by a spring, and as the stator current of the main motor increases, the current in the induction motor of the slip regulator increases. The torque (and hence the displacement) of the rotor varies with the square of the current. A lever attached to the rotor moves the electrodes out of the liquid as the load increases, and the author investigates the law according to which the regulator should be designed, to obtain the desired result. Unlike the case of permanent resistance, the condition now to be aimed at is to secure that the motor torque remains constant. Reference must be made to the original paper for the mathematical analysis of the problems and the formulæ derived. As a numerical example, the formulæ for a motor with permanent resistance are applied to a 20-in., 3-high cogging mill for rolling ingots from 10 × 10 in. to 6 × 6 in. Curves and tables are given for speed, torque, and horse-power. A steel-tube mill is selected as the basis for numerical example relating to the automatic slip regulator system. Finally, the case is considered of an electric winder operating on the Ward-Leonard system with a flywheel on the induction motor shaft and an automatic slip regulator in the rotor circuits.

R. E. N.

809. *Electric Power in Mines.* **C. Jones.** (South Wales Inst. of Eng., Proc. 34. No. 2. El. Rev. 83. pp. 126–127, Aug. 9; 150–151, Aug. 16, and pp. 190–191; Disc., 191, Aug. 23, 1918. Abstract.)—This paper covers a good deal of ground in connection with the use of electricity in mines: the following points, among others, are dealt with, viz. choice of periodicity, improvement of power factor (including the use of static condensers, phase advancers, etc.), earthing the neutral conductor, type of cable to be used, the laying of the cables, installation of junction boxes, the choice and type of transformers and motors, the standardisation of switchgear, the use of liquid controllers, etc. The paper embodies much of the author's practical experience in South Wales.

W. H. S.

810. *The Transmission of Power.* **B. Welbourn.** (Electrician, 81. pp. 181–185, June 28, 1918.)—Electric transmission may be carried out by underground cables or by overhead lines, or by both. The author deals with some of the considerations which must affect the choice. If cables are employed, then the armoured type, laid direct in the ground, is to be preferred. In transmitting large powers special care must be taken to provide for the dissipation of the heat. Overhead lines present certain marked disadvantages, but they would inevitably be used if the pressure exceeded a certain value, say 40,000 volts. As to whether power should be transmitted, or the station placed near the centre of the load, depends finally upon the overall cost. Upon this subject not very much of an authoritative

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character has been published, but in the present article the author gives detailed transmission costs of five schemes. L. H. W.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

811. *The Gotthard Railway Electrification.* (Elekt. Zeits. 39. pp. 261–263, July 4; 275–277, July 11; 283–287, July 18, and pp. 293–295, July 25, 1918.)—Much information is given concerning the history, and the technical and economic features of the Gotthard Railway, with special reference to its electrification. The line, constructed in 1873–97, was taken over by the State in 1909; and the scheme for electrification was accepted about 5 years later. Prior to dealing with the details of the electrification this article gives full particulars concerning the gradients and general lay-out of the line. With the exception of the Brunnen–Fluelen section, the whole 151 km. from Immensee to Bellinzona is double track. The first electrification scheme covered the 109 km. section Erstfeld–Bellinzona, including the Gotthard tunnel; in this short distance the line rises from 475 m. above sea-level to the tunnel (which is 1100–1150 m. above sea-level), and descends again to 244 m. above sea-level. The sharpest curve is 280 m. radius. A Commission appointed to consider the matter concluded that electrification would save 20 to 25 % compared with steam costs, besides accelerating the service.

It was eventually decided to equip the Amsteg and Ritom stations for the direct generation of single-phase alternating current. A summary is presented of the considerations which determined the distance apart of feeding-points. Formulæ and curves are given for the latter for various traffic densities and line voltages; and a number of tables are presented dealing with estimated costs on various systems of operation; traffic capacity of the electrified line; efficiency, power factor, speeds, tractive performance, regenerative braking, and so forth. It is concluded that regenerative braking offers no great advantage so far as the Gotthard line is concerned.

The Amsteg works are designed for a max. load of nearly 20,000 kw., and the Ritom works for over 27,000 kw. Each generator and 66,000-volt transformer forms an electrical unit. Particulars are given concerning the hydraulic features of the stations; the arrangement of substations and distribution network; the rolling stock; and the influence of the traction system on weak current networks. In the latter connection, static induction, dynamic induction, and leakage currents are considered and the weak-current circuits concerned include telegraph, telephone, signalling, and block circuits.

From a detailed statement of capital and operating costs it is concluded that the principal direct items in the annual expenditure are: Wages for maintenance of rolling stock and locomotive operation, 16·2 %; electrical energy, 22·6 %; maintenance and renewals of locomotives, etc., 21 %. The principal indirect costs are: 4 % interest on investment, 20·1 %; renewals fund for rolling stock and lines, 5·9 %. The cost of current is the heaviest item and is made up as follows: Wages, etc., 9·8 %; materials, including running repairs, 17·2 %; water rents, insurance, etc., 11·8 %; interest on plant investment, 48 %; renewals fund, 13·7 %. A sum of 80,800,000 M. (14,000,000 M. for locomotives, etc. and the balance for power stations and workshops, etc.) was voted in 1918. The expenditure of this sum, actual and prospective, is as follows: 1915, 2·4 million M.; 1917, 7·6; 1918, 10·8; 1919, 8·8; and 1920, 1·2 million M. Commencement of electric working on the Erstfeld–Bellin-

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zona section is expected to take place on Oct. 1, 1920. The work is being pushed ahead, in spite of present difficulties.

In a supplement to this article **H. Studer** describes the single-phase locomotives of the Gotthard Railway, including a new Oerlikon one. Four experimental locomotives have been ordered and should soon be delivered. Twenty others are to be delivered during the second half of 1919 and will form the first equipment of the electrified line. It is proposed to work with three types—namely, small and large passenger locomotives and a goods locomotive. The general requirements are as follows:—(1) Passenger locomotives—three double journeys between Lucerne and Chiasso per 24 hrs., allowing 15 mins. at each end of the trip; 480 tons trailing weight; small locomotive coupled in tandem with the larger one on gradients exceeding 21 in 1000. The journey Chiasso–Bellinzona must be made with a trailing load of 350 tons without extra aid. A speed of 50 km./hr. must be obtainable up a gradient of 26 in 1000 with 215 tons trailing load in the case of the small and 300 tons in the case of the larger locomotives; max. speed 75 km./hr. (2) Goods locomotives—two double journeys between Goldan and Chiasso per 24 hrs. with 860 tons trailing load: a pusher being used on gradients exceeding 21 in 1000. One of these is to be capable of hauling 625 tons on the Chiasso–Bellinzona route. A load of 480 tons must be hauled at 35 km./hr. on a gradient of 26 in 1000. Max. speed 65 km./hr.—The permissible load is 18 tons on a driving axle and 12 to 16 tons on a trailing axle. In the goods locomotives, the two middle axles (2 m. apart) may be loaded to 19 tons if the end axles be loaded only to 17 tons.

R. E. N.

812. *Overhauling of Waterwheels during the Dry Season.* **C. A. Graves.** (El. World, 72. p. 203, Aug. 3, 1918.)—A description with a plan and diagram of the rearrangement of the steam and hydroelectric plant of the Southern New York Power Co. at Deposit, N.Y., on the Delaware River. In the original plant three 42-in. waterwheels were bevel-geared to a horizontal shaft, belted to a jack shaft, from which two 100-kw. generators were belt driven. One 80-h.p. horizontal steam engine and one of 300 h.p. were also belted to opposite ends of the jack shaft. With this plant the average coal consumption for six years was 824 tons per year, and there was no surplus water-power capacity. After a fire in 1914 the units were regrouped, the three waterwheels being belted to one 200-kw. generator through the medium of the jack shaft. The 80-h.p. and 300-h.p. horizontal engines were respectively direct-connected to 50- and 250-kw. generators. The saving of fuel with this rearrangement has been over 600 tons per year, a large part of this being due to the improvement in the waterwheel equipment. The steam plant is used during peak loads.

W. E. W.

813. *Remodelling the Hochelaga (Montreal) Power Plant.* (El. Rly. J. 51. pp. 1085–1090, June 8, 1918.)—This plant was installed in 1906 to supply East Montreal as a standby to the water-power service. The original plant comprised two 1000-kw. and one 2000-kw. marine type compound d.c. sets. The remodelled plant, on the same site which adjoins the St. Lawrence, will contain four 15,630-kv.a. turbo-generators, so far the largest installed in Canada. The unit system has been adopted, comprising boilers, heaters, feed pumps, condensing apparatus, air washers, and turbo-generators. Energy is generated direct at the transmission voltage of 18,200, thus obviating step-up transformers. The turbines have a full-load rating of 12½ lbs. of

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steam per kw.-hr. with steam at 190 lbs. per sq. in. and 150 deg. F. superheat. An air intake chamber is provided in the turbine-room, and air is drawn from outside 8 ft. above ground-level, passes through the generators and is discharged into the boiler-room basement whence it passes to the stokers; this arrangement muffles the noise and warms the air for the stoker blowers. There is a difference of 31 ft. between the flood and low levels of the St. Lawrence River, and advantage is taken of this by placing the condensers in a well to obtain siphon action with the circulating water, thereby saving one-half the power.

In the boiler-house there has been adopted a combination of a low ejector type stack, steel tube economisers, and chain-grate stokers of relatively large grate area set in a furnace embracing the entire base of the boiler, *i.e.* the full tube length and breadth. The heating surface of each boiler is 5620 sq. ft., and with coal of 18,500 B.Th.U. and 70 % combined efficiency of grate boiler and economisers, the combustion rate is 17 lbs. of fuel per sq. ft. of grate surface.

The auxiliaries are motor and turbine driven, and the exhaust from the turbine which drives the combined air and condensate pumps is piped so that it may be discharged to the open heater or into the intermediate stage of the main turbine. W. E. W.

814. *Hydroelectric Power in France.* **H. Cahen.** (Rev. Gén. d'El. 4. pp. 393–400, Sept. 14, 1918.)—This is a discussion of the question played by electro-hydraulic power in France during the war, where their coalfields have been largely closed. The author gives a number of particulars and statistics relating to the matter, and considers that hydraulic power will be of great use to the country in the years after the war. The largest amount of available water is situated in the valley of the Rhône, but the Garonne, Loire, and other rivers also contribute. W. H. S.

815. *Power Transmission from Bitterfeld to Berlin.* (Elekt. Zeits. 39. p. 807, Aug. 1, 1918.)—Power is transmitted at 110,000 volts over a distance of 180 km. The line consists of 8 Al cables of 120 mm.^{2} section; they are carried on iron poles: above these is an iron earthing wire 50 mm.^{2} section. The power amounts to 20,000 kw.: three further cables can be carried. The transformers have windings of Al. The station in Berlin is very simple and compact, power being distributed at 6000 volts. It is calculated that this scheme dispenses with the necessity of conveying between 300 and 400 tons of coal to Berlin daily. W. H. S.

816. *Substation Equipment for Chicago, Milwaukee and St. Paul Railway.* (El. Rly. J. 51. p. 1198, June 22, 1918.)—These substations are on the Columbia River section, and are supplied with 3-phase power at 102,000 volts from the hydroelectric station on the Spokane River. This is transformed to 2300 volts, and then converted by motor-generators into direct-current at 3000 volts. The incoming h.t. line enters the substation through bushings of the condenser type; there is a transformer for each motor-generator set, and there are no low-tension bus-bars. There are three substations in all, with a total capacity of 14,000 kw. The transformers have outputs of 2500 kv.a.; the motor-generators are 2800-h.p. with a 14-pole synchronous motor coupled to two 1000-kw. 1500-volt d.c. generators, coupled in series. The normal rating of these sets is 2000 kw., but they can give 3000 kw. for 2 hours and 6000 kw. for 5 mins. Owing to the regenerative system, the generators sometimes act

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as motors and are shunt-wound. Under heavy loads, they have forced ventilation, the air being supplied by separate motor-driven blowers. A number of other details are given, relating to switches, automatic circuit-breakers, lightning arresters, etc. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

817. *Saving by Correct Operation of Car Equipment.* **C. W. Squier.** (El. Rly. J. 52. pp. 275–277, Aug. 17, 1918.)—Energy wasted in car operation includes losses in grid resistors, iron and copper losses in motors during acceleration, and energy absorbed in braking and dissipated as heat in brake-shoes and wheels. The useful energy is that used in overcoming train resistance, including resistance due to grades and curves. Curves are given, showing the effect on power input of varying the cycles of operation. Economies result from increasing schedule speeds with the rate of acceleration; from using higher acceleration and braking rates; and from reducing the duration of stops.

The aim of control designers is to increase the car speed uniformly und as quickly as consistent with reasonable current peaks, wheel slippage, and passenger comfort. The only way to secure a definite manipulation of the controller is to make the apparatus automatic in action. For a given average rate of acceleration the same amount of energy is wasted every time the car is started, independent of length of run, stops per mile, rate of braking or length of stop. On longer runs this constant rheostatic loss is a smaller percentage of the total power used; hence the economy of rapid acceleration is most apparent on short runs. There is little advantage, however, in accelerating at rates exceeding 1 to 1¼ miles/hr. per sec. If the schedule speed be increased as the rate of acceleration is raised, the same service may be rendered by fewer cars. Examples are given to illustrate the savings possible in this and other directions. It is advantageous to keep the accelerating rate as high as is permitted by the equipment, and energy is saved by cutting off power as soon as possible, and coasting for as long as possible (*i.e.* working with a high rate of retardation). Experience on surface lines shows that the most economical braking rate lies between 1¼ and 2½ miles/hr. per sec. The number and length of stops influence the size of motors, the energy consumed, the schedule speed obtained, the number of cars required for given service, and the capacity of line and power-house. This is one of the largest fields for operating economies that can be found in electric tramways to-day. R. E. N.

818. *Axle-driven Generators on the Chicago, Milwaukee and St. Paul Railway.* (El. Rly. J. 52. pp. 289–290, Aug. 17, 1918.)—These generators are mounted on and geared to the trailing axle of the guiding trucks, and are used for the excitation of the fields of the main motors, and for driving auxiliary motors for compressors and blowers. The generator fields are excited from a storage battery, and the voltage is controlled by a power-operated rheostat automatically controlled during the time the machine gives current to the auxiliary motors and manually controlled during regeneration. The fact that the auxiliary apparatus works at low voltage, which is practically independent of the line current, is considered to be an advantage. W. H. S.

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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819. *Electrification on the Norfolk and Western Railway.* (El. Rly. J. 52. pp. 322–325, Aug. 24, 1918.)—This article shows some of the results obtained on this line. The cost of freight movement is now found to be 26 % less than if steam were used, but figures of this kind depend on the amount of traffic handled. The line hauls large quantities of coal for naval purposes, and now deals with 50 % more than was possible with steam, partly on account of difficulties connected with a certain tunnel, where the steam locomotives were liable to come to a standstill. Many other facts and figures relating to the comparison between steam and electricity are contained in the article, which has a plan of the line and a diagram of gradients.
W. H. S.

820. *The Economies resulting from "Coasting."* **H. C. Kendall.** (El. Rly. J. 52. pp. 51–54, July 13, 1918.)—This mainly concerns the experience of the Denver Tramway System, where in 1912 the average coasting was 10 %, while in 1915 it amounted to an average of 39 % throughout the year. The cost of renewal to brake-shoes has in the same time dropped by 40 %. As it seemed that there might be a doubt about these figures, a committee was appointed to investigate, and test: their conclusions and tests, together with many curves and figures, are given in the present article. A description is also given of the manner of training the drivers. The power consumed per car-mile in 1912 was 3·06 kw.-hrs., and in 1915, 2·68 kw.-hrs., in spite of increased use of power for heating and auxiliaries. W. H. S.

ELECTRIC LAMPS AND LIGHTING.

821. *Standardisation of Screw Threads for Edison Lamp Caps and Holders.* **C. Zetter.** (Rev. Gén. d'Él. 4. pp. 9–21, June 6; 39–49, July 13; 73–84, July 20, and pp. 105–115, July 27, 1918.)—This paper constitutes what is probably the most complete collection of data yet published concerning standardisation of Edison screw lamp-caps and holders in various countries. The standards proposed by the Union des Syndicats de l'Électricité are compared with those of the Compagnie générale d'Électricité; the American Standards Committee; the British Engineering Standards Committee; and the German V.D.E. Special attention is paid to the dimensions used in South America, Spain, Portugal, Russia, and Belgium—these countries representing markets into which it is hoped to carry French products. The report includes standard symbols and designations; large-scale dimensioned illustrations of profiles, thicknesses, clearances, etc.; and a number of comparative tables. The genesis of the Syndicats' standards is given in detail, and this system is compared thoroughly with the other standards extant. Goliath, standard, small and miniature caps and holders are considered; and the question of gauges and limits is discussed in detail. R. E. N.

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TELEGRAPHY AND TELEPHONY.

822. *Scientific Signalling and Safety at Sea.* **J. Joly.** (Phil. Mag. 36. pp. 1–86. July, 1918. Tyndall Lectures delivered at the Roy. Inst., April, 1918.)—A more detailed discussion of the method of emitting simultaneous acoustical and Herzian signals, dealt with in Abs. 226A (1916). The application of the method to the avoidance of collision at sea is dealt with elsewhere at greater length (Roy. Soc., Proc. 94. pp. 547–560, Aug., 1918).

L. H. W.

823. *Maximum Regulating Resistance and Maximum Shunt Resistance of Track Circuits.* **W. J. Thorrowgood.** (Electrician, 81. p. 292, Aug. 2, 1918. Abstract of paper read before the Inst. of Rly. Signal Engin.)—The max. shunt resistance of a track circuit is that resistance which, if placed across the track rails, causes sufficient current to pass through the regulating resistance (including internal resistance of battery) to increase the D.O.P. on the regulating resistance so that the D.O.P. on the terminals of the relay falls to the "drop away" voltage. This is generally spoken of as the "shunt resistance" as it is thought to shunt the current from the relay.

In designing a track circuit it is of the utmost importance that the max. shunt resistance should be as high as possible, to allow of any slight variations due to weather, and for light vehicles, sand or rust not interfering with the operation of the track circuit; also to make it certain that even a slightly dirty rail or wheel will not result in a false clear signal. The max. shunt resistance aimed at in practice is about 2 ohms, but many track circuits have a much lower shunt resistance than this. The max. shunt resistance depends upon: (1) the e.m.f. used in the track circuit; (2) the pick-up and drop-away current of the relay; (3) the resistance of the relay; (4) the regulating resistance in series with the battery; (5) the insulation resistance of the track circuit, and (6) indirectly, the strength of stray currents.

The author discusses the influence of these factors in detail and states his convictions as follows:—(1) It is advantageous to use the max. value of regulation resistance. (2) Increasing the e.m.f. when the max. regulation resistance is used increases the max. shunt resistance. (3) It is necessary that the insulation resistance of the track circuit shall be as high as possible. (4) The 4·5-ohm track relay gives the highest results as regards max. shunt resistance of track circuits. (5) The max. shunt resistance can be easily improved by one or other of the methods discussed, and the best results are obtained (*a*) by inserting additional regulating resistance at the battery end of the track, or (2) by adding resistance between the rail and track relay, in series with the relay, after the relay has started to pick up. H. H. H.

824. *Comparative Experiments on Audions.* **G. Vallauri.** (Jahrb. d. Drahtl. Tele. 18. pp. 25–60, May, 1918.)—A translation of the work dealt with in Abs. 646 (1917).

825. *Inductive Effects of A.C. Railways on Communication Circuits.* **H. S. Warren.** (Am. I. E. E., Proc. 37. pp. 1019–1048, Aug., 1918.)—One important kind of inductive disturbance on telegraph and telephone lines is that arising from installations of a.c. railway electrification.

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Telephonic currents vary in frequency from 200 to 4000 or more periods per sec. Signalling impulses on telegraph lines are complex, but their most important components are of less than 800 periods per sec.

Power circuits are commonly of either 25 or 60 periods per sec., but harmonics are prevalent. It is due to the presence of harmonics that noise is produced in telephone currents by induction. Care in design of the power machinery so as to reduce the proportion of such harmonics makes it possible to avoid much of such disturbance. If one of the power conductors breaks, or the earthing of same takes place, surges in adjacent communication circuits are set up which may represent relatively large amounts of power.

Power-circuit voltages and currents may be classified under two heads: (1) Balanced voltages and currents, that is, those which are balanced or symmetrical with reference to the earth, and (2) residual voltages and currents, that is, those which are wholly unbalanced with reference to earth. At every instant the algebraic sum of the balanced currents and also the balanced voltages is zero. Hence at any instant the algebraic sum of the currents in the line conductors is the residual current and, similarly, the algebraic sum of the voltages to earth of the line conductors is the residual voltage. For example, in the ordinary railway circuit with overhead trolley wire and earthed rail return, all the voltage and all the current is residual.

The author considers modifications in the design and arrangement of the power apparatus to reduce or eliminate residuals such as the triple harmonics encountered in star-connected transformer banks, also the want of balance in the power circuit itself. Transposition of the power circuit is advocated. To make such transposition effective, it is necessary that the intervals chosen be short in comparison to the wave-lengths of the harmonics. He then goes on to consider: Unbalance of communication circuits; transpositions; length of parallel; configuration of the power line; wave shapes; terminal apparatus; voltages and currents of power circuits under abnormal conditions; the relative cost of preventing interference. He finally discusses means of prevention applicable to the power circuit and some applicable to the communication circuit, such as: Neutralising transformers; sectionalisation of telephone circuit; shielding conductor; resonant circuits; double trolley; sectionalisation of trolley system; and concludes with a description of four important railroad installations and the means adopted in each case for preventing interference, together with the degree of success met with.

H. H. H.

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SCIENCE ABSTRACTS.

Section B.—ELECTRICAL ENGINEERING.

DECEMBER 1918.

PRIME MOVERS.

STEAM PLANT.

826. **25,000-*kw*.** *Turbine Damaged.* (Power, 48. pp. 425–426, Sept. 17, 1918.)—One of two 25,000-kw., 1800 revs. per min., single-cylinder impulse turbines in the new West End Station of the Union Gas and Electric Co., Cincinnati, was badly damaged in the 17th (last) stage on Sept. 4th. The diaphragm, with 350 buckets, was distorted top and bottom, causing the wheel blades to rub it, crushing and burning the buckets. The turbine, installed about 2 months, had been carrying trial loads satisfactorily. The load at the time of the accident was 20,000 kw. The 17th is the only stage damaged. The 200 wheel blades are 28 in. long, of steel with shrouding. About every tenth blade is broken off cleanly, immediately above the fastening to the wheel. The diaphragm is 11 ft. in diameter overall and the rim speed of the disc is 1000 ft. per sec. The damaged disc was removed and the turbine working again within five days of the accident. W. N. Y. K.

827. *Development of the Steam Turbine.* (El. Rev., Chicago, 73. pp. 612–614, Oct. 19, 1918.)—Reviews briefly the improvements in turbine design and indicates probable lines of development. To-day 5000-kw. 60-~ machines work at 3600 revs. per min.; formerly 1800 revs. per min. was considered a high enough speed. The max. capacities of generators at given speeds are as great as turbines can be designed for. All turbines now have automatic stop gear fitted to the main throttle valve, ensuring freedom of motion of the pistons. Monel-metal valve seats appear to resist best the erosive action of steam. The hot and cold spots when operating at light load have been eliminated. With large turbines delivering to the switchboard 76 to 80 % of the theoretical energy available little further improvement is to be expected in the machine itself. Attention is being paid to using higher steam pressures up to 600 lbs. per sq. in. Steam at 600 lbs. and 128 deg. F. superheat has the same heat-content as steam at 200 lbs. and 200 deg. F. superheat, but is capable of giving 18 % more energy when expanded down to 29 in. vacuum. The efficiency of the turbine, however, is reduced on account of the greater

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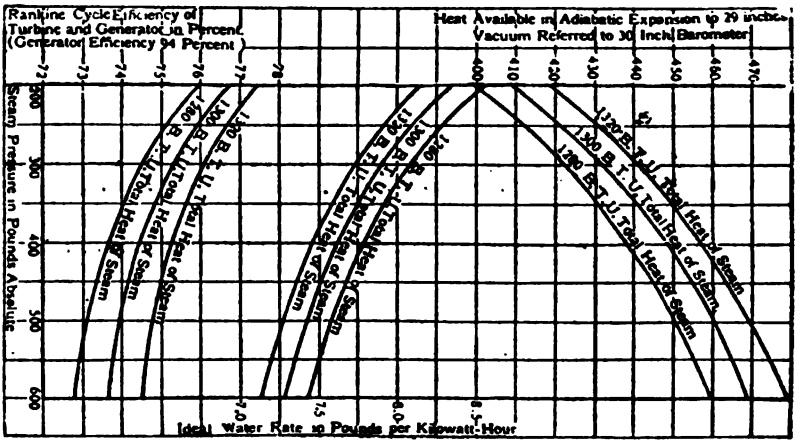
density of the steam in the h.p. portion and the greater deposit of water in the l.p. portion, so the net saving will probably be only 6 or 7 %. Three sets of curves show the changes of Rankine cycle efficiency, ideal water rate and


Rankine Cycle Efficiency of Turbine and Generator in Percent (Generator Efficiency 94 Percent)
Heat Available in Adiabatic Expansion to 29 inches Vacuum Referred to 30 Inch Barometer
Steam Pressure in Pounds Absolute
Ideal Water Rate in Pounds per Kilowatt-Hour
1,190 B.T.U. Total Heat of Steam
1,190 B.T.U. Ideal Heat of Steam
1,190 B.T.U. Total Heat of Steam
1,190 B.T.U. Ideal Heat of Steam

heat available for steam pressures between 200 and 600 lbs. per sq. in. Single and multiple unit designs for large turbines are discussed. The future developments are likely to make for greater reliability and economy. with tendency to increased cost. W. N. Y. K.

828. *Effect of the Mass of the Moving Parts in a Driving System.* **H. Lorenz.** (Zeits. Vereines Deutsch. Ing. 62. pp. 562–567, Aug. 24, 1918.)—Proves that the effect of the mass of a driving rod, the ends of which are constrained to move along certain paths, is divided equally between the two crank pins at its ends only when the centre of inertia of the rod lies on the straight line joining the pins in such a position that the period of oscillation of the rod about each pin is the same. The application of this principle in practice is then considered. J. W. T. W.

829. *New System of Regenerative Evaporation.* **W. L. De Baufre.** (Am. Soc. Mech. Eng., J. 40. pp. 746–749, Sept., 1918.)—The Regenerative Evaporator Co., Baltimore, Md., has patented a new system of regenerative evaporation in which the essential feature is a highly efficient steam-jet compressor known as the "Jet-flo." When this is applied to an evaporator the steam economy of a multiple-effect plant is obtained with greater simplicity of operation than with the ordinary single-effect plant. The apparatus is illustrated and its action described. Test results show that the steam economy was practically constant over a wide range of pressures and that the capacity was nearly proportional to the absolute steam pressure.

The working and design of evaporators are discussed. The application of the new system to naval vessels, particularly destroyers, where two evaporators are installed for double-effect operation, enables either evaporator to be worked at triple-effect efficiency, resulting in a saving of 100 galls. of fuel oil in 7500 galls. per day as compared with double-effect, and 400 galls. as compared with single-effect operation. On merchant vessels coal used for this purpose is reduced by 50 % or more. W. N. Y. K.

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830. *Correcting the Causes of Low Vacuum.* **H. Le H. Smith.** (El. Rly. J. 52. pp. 500–504, Sept. 21, 1918.)—Describes means of diagnosing the causes of low vacuum. The best vacuum obtainable in any plant varies greatly during the year. Before the quality of a vacuum can be judged the records obtained in the plant must be analysed and the performance compared with the best previously obtained. This is shown by the heat-balance equation:

$$[SH - (8412/E)L] + W(t_1 - 32) = W(t_2 - 32) + S(t_3 - 32),$$

where S = steam consumption, lbs. per hour; L = load, kw.; W = quantity of condensing water, lbs. per hour; H = total heat above 32° F. in steam delivered to turbine, B.Th.U. per lb.; t_1 = condensing water temp. at inlet; t_2 = condensing water temp. at outlet; t_3 = temp. of water leaving condenser hotwell; E = combined efficiency of turbine and generator expressed as a fraction.

The main point is the great significance of the inlet temperature of the condensing water. This varies considerably, and readings should be taken and plotted against the turbine exhaust vacuum over a long period for comparison with any one performance. The rate of supply of condensing water is very nearly inversely proportional to its temperature-rise for a given load, so that it is a simple matter to trace if low vacuum is due to shortage of circulating water. The period of working since the last tube cleaning is an important factor, as are also air leakage and inefficiency of air-pump action. Cleaning the tubes externally by filling up the condenser steam space with a suitable solution, such as sodium bisulphate, is effective and not injurious. W. N. Y. K.

831. *Selecting Steam Condensers.* **D. D. Pendleton.** (El. World, 72. pp. 788–789, Oct. 19, 1918. Paper read before the Assoc. of Iron and Steel El. Eng.)—Maximum overall efficiency cannot be attained in power plant operation unless condensers of correct type and design are chosen for each plant. The original paper includes a comprehensive discussion of surface condensers, low-level jet condensers and barometric condensers. Requirements should not be made so high that the cost is not justified by the increased economy effected. A reciprocating engine is seldom proportioned to utilise a vacuum higher than 26 or 27 in., whereas a steam turbine is designed to utilise the highest vacuum obtainable. Barometric condensers may be used with very bad, dirty, or acid water, provided that the tail pipe is large enough to carry off water and debris by gravity without clogging; a vacuum of 28½ in. is easily maintained so long as the exhaust pipe is not more than 5 ft. in diameter.

The low-type jet condenser has the same advantages and disadvantages as the barometric type; the tail pump should keep the outgoing water well ahead of the incoming water, and 140,000 lbs. of steam per hr. (10,000 kw.) is about the practical limit of size for jet condensers.

Dirty or acid water may not be used in surface condensers, but there is no limit to the size of the latter, units being built from 50 sq. ft. of surface up to 75,000 sq. ft. (corresponding to 600,000 lbs. of steam per hr. or 50,000 kw.). Surface condensers entrain only about half as much air as either the barometric or jet condenser. A water velocity of 5 ft. per sec. is about the average for surface condensers; velocities of 8 to 10 ft. per sec. assist in keeping tubes clean, but the excessive power required to maintain such velocities is more costly than mechanical cleaning. In a number of typical cases, the condenser surface ranges from 1·14 sq. ft. to 1·66 sq. ft. per

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kw. The steam condensation per sq. ft. per hr. is 5·4 to 8·5 lbs., where the vacuum is about 28 in. and the temperature of the circulating water inlet about 75° F.

Roughly 90 % of steam heat delivered to auxiliaries is returned to the hot well; by using some electrically driven auxiliaries, the risk of having an excess of exhaust steam during light loads is eliminated. In some cases exhaust steam may be passed to an intermediate stage of the main turbine. A comparison of different types of condensers with regard to the amount of auxiliary power required is as follows:—

	Surface.	Jet.	Barometric
	Kw.	Kw.	Kw.
Water supply and tail pump	152	467	352
Condensate pump	84	—	—
Rotative dry-vacuum pump	86	114	114
Turbo air-pump	197	256	256
Steam jet	215	250	250

The total power required to drive auxiliaries for the three types of machines for a 10,000-kw. turbine varies from 2·7 to 4 % with the surface, 5·8 to 7·2 % with the jet, and 4·7 to 6 % with the barometric condenser. R. E. N.

832. *The Economical Use of Fuel.* (Am. Soc. Mech. Eng., J. 40. No. 7. pp. 608–660, 1918. Discussion.)—This symposium on the use of fuel contains selections from the discussions received in response to a questionnaire sent out. The topics upon which discussion was solicited are 19 in number, of which the most important are: (1) What are the economic effects of impurities in coal? (2) To what extent is fuel oil likely to be used as a substitute for coal? (3) What are the possibilities in the direction of the utilisation of anthracite wastes? (4) What instruments are useful and desirable in the boiler room? (5) What is essential to the economical operation of hand-fired boiler furnaces when using soft coal? (6) To what kinds of plants and coals are the different mechanical stokers respectively adapted? (7) What coal economies can be effected in small steam plants? (8) To what extent will the gas producer be used to produce economies? (9) What are new important developments in methods of burning coal? (10) Is automatic air supply correctly proportioned to air supply possible? L. H. W.

833. *Results with Pulverised Coal.* (Power, 48. pp. 556–559, Oct. 15, 1918. El. World, 72. pp. 744–745, Oct. 19, 1918.)—The Milwaukee Electric Railway and Light Co. has installed a pulverised coal plant at the Oneida St. Station in connection with 500-h.p. Edge Moor boilers. The boiler with pulverising plant was put into service last May and after some alterations proved quite successful. The equipment, to serve 5 boilers, comprises an indirect-fired drier of 15 tons per hour capacity and two pulverisers, one of 4 tons and the other of 8 tons' capacity. Between the drier and pulverisers the fuel is run over a magnetic separator pulley. A blower and two screws driven by variable-speed motors feed the fuel into the furnace. The boiler setting required very little alteration to adapt it to the pulverised coal. The burner is placed at the top of the furnace and discharges downwards. The furnace volume is about 1700 cub. ft., and the heating surface is 4685 sq. ft. The feeders and burners are of the "Lopulco" type. When first tried insufficient

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air supply caused high furnace temperature and accumulation of slag between the tubes and on the furnace walls; also the combustion chamber was found too small, so that the surfaces were soon destroyed. These defects were rectified and efficiency tests were run. Table I gives some of the results obtained.

A comparison is made between the use of pulverised coal and mechanical stokers. With pulverised coal it is estimated that 82 cents per ton will cover the cost of drying and pulverising under given conditions and maintenance will be covered by 8 cents per ton. There is no loss at any time through clinkering. From 97 % to 98 % of the combustible is utilised, regardless of the quality of the fuel, and ashes are reduced to a minimum. By stopping fuel supply and closing all dampers and air inlets a boiler can be kept up to pressure for about 10 hours.

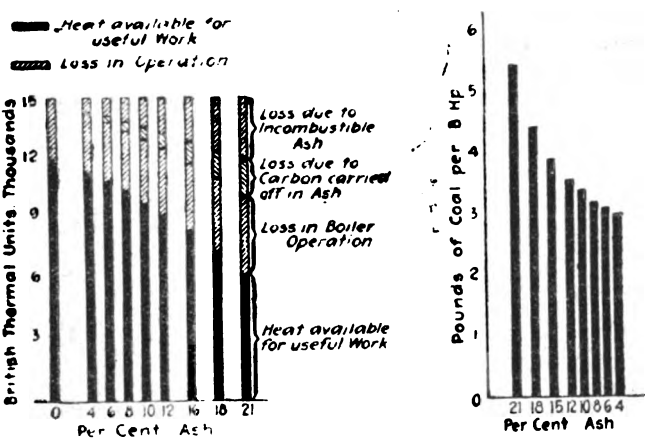
TABLE I.

LOG OF OFFICIAL TEST AT ONEIDA ST. STATION.

Heating surface, sq. ft.	4685
Average boiler pressure, lbs. per sq. in.	167·0
Fuel (100 % bituminous coal) fired per hour, lbs.	1990·6
Water evaporated, actual, lbs. per hour	16,892·0
„ „ per lb. coal, lbs.	8·28
Factor of evaporation	1·1502
CO_2 per cent., average	13·85
O, per cent., average	4·88
CO	0·0
Net efficiency of boiler, %	81

W. N. Y. K.

884. *Excessive Ash in Coal.* (El. Rly. J. 52. p. 504, Sept. 21, 1918.)—Gives a brief summary of a study made by the J. G. White Engineering Corporation for the U.S. National Research Council of the losses due to high percentage



of ash-content in coal. Two charts show the effect of varying percentage of ash on: (1) Heat available for useful work, and (2) Coal consumption per boiler horse-power. W. N. Y. K.

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PROPERTIES OF ENGINEERING MATERIALS.

835. *Stellite. Alloys of Cobalt, Chromium, Tungsten and Molybdenum.* **E. Haynes.** (Met. and Chem. Eng. 18. pp. 541–542, May 15, 1918.)—The alloy stellite was developed from original experiments on Co-Cr alloys by the addition of W and Mo. Such alloys can be cast in various forms and show the property of retaining a keen cutting edge to such an extent that they can be used for tools and for surgical and dental instruments. The alloys are unattacked by the atmosphere. F. C. A. H. L.

836. *Steels for Gears and their Treatment.* **G. A. Richardson.** (Am. Machinist, 49. pp. 1–8, July 4, 1918. Am. Soc. Mech. Eng., J. 45. pp. 721–722, Aug., 1918. Abstract.)—Gears are divided into two classes: (*a*) those used merely for changing speeds, and (*b*) those used for power transmission. For the first class the cheapest material consistent with convenience is the best, but in the second class it is necessary to consider whether resistance to wear or resistance to shock is of primary importance. Oil-hardened gears will give greater resistance to wear than case-hardened material.
F. C. A. H. L.

837. *British Scientific Products Exhibition.* (Engineering, 106. pp. 177–178, Aug. 16; 211–212, Aug. 23; 233–236, Aug. 30, and pp. 246–251, Sept. 6, 1918.)—A general descriptive account of the more interesting of the exhibits.
L. H. W.

838. *Note on the Formation of Coke.* **G. Charpy** and **M. Godchot.** (Comptes Rendus, 167. pp. 822–824, Aug. 26, 1918.)—The results obtained by the authors prove that a coal which in the natural state is quite useless for producing hard coke can, by means of a preliminary heating to 450 deg. C., be converted into one which will yield a coke of normal quality and hardness. The importance of carrying out preliminary trials with various coals and mixtures in order to ascertain the best conditions and proportions for carbonisation is also emphasised by these tests, and the authors claim to have indicated a simple and easy method for this purpose.
J. B. C. K.

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GENERAL ELECTRICAL ENGINEERING, INCLUDING INDUSTRIAL ELECTRO-CHEMISTRY.

839. *Effect of Lithium upon the Capacity of the Edison Storage Battery.* **L. C. Turnock.** (Am. Electrochem. Soc., Trans. 32. pp. 405–412; Disc., 412–413, 1917.)—Experiments upon a very small cell are described in which the electrolyte consisted of a 21 % solution of caustic potash and varying amounts of lithium hydrate. These amounts were 10, 20, 30, 40 and 50 gm. per litre. In the commercial cells it appears that the last-named quantity is employed. It was found that although the lithium hydrate increases the internal resistance it also increases the available capacity. This increase amounted to 12 % (with an increase of 21 % in the resistance) by the addition of 50 gm. of the hydrate. W. R. C.

840. *The Function of Barium Sulphate in Accumulators.* **O. Scarpa.** (Elettrotecnica, 5. pp. 871–872, Sept. 25, 1918.)—Some large batteries of accumulators constructed by one of the best known firms in Italy showed the unexpected phenomenon that their capacity, which should have remained constant for at least 200 discharges, rapidly diminished so that after 100 discharges they had a capacity of only 40 % of the initial value. The author found that its cause had to be attributed to the physical properties of the barium sulphate mixed with the lead oxides of the negative plates in order to render the mass more porous. Before the war the barium sulphate employed for this purpose came from Germany; that employed in the batteries considered, which had been constructed during the war, was made in Italy, and though its chemical properties were the same as the sulphate of German origin, its physical properties were different. Microscopic observations showed that the function of the barium sulphate was to prevent the "soldering," so to say, of the lead particles of the negative paste; this purpose is more or less effected according to the physical properties of the barium sulphate, properties which were determined by the author, but which are not spoken of in the article. Bad barium sulphate allows the lead particles to become "soldered" to one another and the soft lead to be transformed into hard lead.

Special elements, constructed according to the author's views, showed the correctness of the latter. E. B.

841. *Manufacture of Ferro-alloys in the Electric Furnace.* **R. M. Keeney.** (Am. Inst. Mining Eng., Bull. No. 140. pp. 1821–1873, Aug., 1918.)—This paper contains a great deal of detailed information which it is impossible to present in the form of an abstract. The author does not attempt to cover the manufacture of ferro-alloys beyond the metallurgical side, nor are furnaces discussed. The greater part of the data are from commercial operations. The metallurgical problems encountered in the manufacture of ferro-alloys have been the production of an alloy with a low percentage of carbon, a high percentage of the alloying element, and a low percentage of impurities, such as P and S, that might be injurious to the steel. The alloy should have a melting-point low enough to be used in a steel bath of ordinary temperature. To obtain this feature it has been necessary, in some cases, to produce an alloy with a high percentage of carbon and a comparatively low percentage of the alloying element, for example, ferro-

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titanium. The ferro-alloys with a low percentage of carbon are considerably more expensive than the high-carbon alloys, because of the extra refining necessary, which requires a large power consumption, and to a small extent increases the losses. In the case of some alloys, for example, ferro-vanadium and ferro-tungsten, the steel manufacturer will not accept a high-carbon alloy, *i.e.* containing over 1 % of carbon, under any conditions, because of the tendency to form carbides in the steel. It is also essential to produce a ferro-alloy of uniform composition, a difficult feature with some alloys. A ferro-alloy which is not fairly uniform is a source of trouble and expense in the manufacture of alloy steel, because it is not possible to regulate closely the composition of the steel.

Carbon control in the electric furnace depends upon two possible characteristics of the alloying metal: First, does it form carbides? Second, is the alloying metal easily oxidised? Some metals, such as Cr, Mn, U, and V, form carbides, even in the presence of a small amount of carbon at the temperature of the electric furnace, resulting in a high-carbon alloy. Some ferro-alloys, when refined to diminish the carbon, show a tendency to lose the alloy metal, because it oxidises into the slag. There are three general methods of producing low-carbon ferro-alloys: (1) The ore may be smelted with excess of carbon to produce a high-carbon alloy with a low slag loss; after breaking up this high-carbon alloy, it may be charged with oxidising slags to remove the carbon in a refining furnace. (2) The ore may be smelted with about the theoretical amount of carbon to produce a 1 % carbon alloy with a high slag loss, but not followed by any refining process. (3) The ore may be smelted with a metal powder, such as Si or Al, which reduces the metal to a product low in carbon, but high in Si or Al, with a low slag loss; after breaking up this impure alloy, it can be charged with an oxidising slag to remove the Si or Al in a refining furnace. When using Al, it is not usually necessary to adopt a refining operation. W. R. C.

842. *Electric Furnace Problems.* **J. L. McK. Yardley.** (Am. Inst. Mining Eng., Bull. No. 142. pp. 1593–1598, Oct., 1918.)—An example is given of the calculation of the inductance of an electric furnace, and the results obtained are compared with those found by measurement in the case of two furnaces which are in operation. W. R. C.

843. *Design and Operation of a Small Kjellin Furnace.* **G. H. Stanley** and **W. Buchanan.** (Met. and Chem. Eng. 18. pp. 416–420, April 15, 1918. Combined Abstracts from Chem. Met. and Min. Soc., S. Africa, J. and S. African Inst. of El. Eng., J.)—This article is the continuation of the one to which reference was made in Abs. 493 (1918). Particulars are now given of the energy required, the determination of the inductance, open-circuit current, and power factor. In referring to the pinch effect the authors point out that there is a bodily force acting on the molten conductor due to the repulsive effect from the unlike current of the primary. The magnitude of this force, with 80,000 amps. in conductors 14 in. apart, is 2·88 lbs. per inch of circumference. With a full channel of 72 in. section the same pressure would be produced if the molten metal revolved at a speed of about 14 r.p.m. The elevation of the outer edge when the metal is very fluid has no doubt given rise to the mistaken idea that the metal revolves bodily. The authors also consider in a general way the saving to be effected by the pre-heating of scrap and they give details of operating tests and operating costs.

W. R. C.

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844. *The Electric Furnace in the Development of the Norwegian Iron Industry.* **H. Styri.** (Am. Electrochem. Soc., Trans. 32. pp. 129–139; Disc., 139–140, 1917.)—This is mainly a brief history of the electric furnace in the Norwegian iron industry. In referring to the Rennerfelt furnace the author states that there is very little advantage in the special feature of this furnace, namely, the arrangement of electrodes for throwing the arc against the bath, as this can be obtained with single or polyphase currents when the electrodes are placed at an angle to the charge. The arc will follow the path of least resistance, and that is where the gases are hottest between the electrode ends and the bath. When melting down cold scrap the arc in the Rennerfelt furnace is not more steady than it is, for instance, in the 3-phase Héroult furnace, because of the cooling of the air from the charge with consequent unsteady air currents. Moreover, the lining is very much exposed to radiant heat.

W. R. C.

845. *Electric Pig-iron.* **R. Turnbull.** (Am. Electrochem. Soc., Trans. 32. pp. 119–123; Disc., 123–127, 1917.)—The author gives results of the production of pig-iron from steel scrap. The furnace in use has a capacity of 6 tons and is 3-phase. The operation is similar to that of making steel, but the refining process for the elimination of phosphorus is somewhat different. The charge consists of shell turnings, the necessary carbon base (which may be charcoal, coke or coal), ferro-silicon, and lime. Manganese is unnecessary as the existing Mn in the steel is conserved. The furnace is of the fixed type with a carbon bottom and silica-brick lining with automatic regulators. The loss in steel amounts to about 10 % of the scrap charged. The resulting pig-iron is very tough. The carbon is rarely over 3 %, and any increase in the carbon is very destructive to the lining and roof of the furnace. The cost of production is high and would be prohibitive under normal conditions. In the *discussion* the author mentioned that the number of kw.-hours per ton is a little less than 550, the load factor for the month being 58 %. Roof-cooling rings round the electrodes have been found effective providing there is proper water circulation, and they give increased life to the roof; a life of 260 heats has been reached. The reason for manufacturing pig-iron in this way rather than steel is that in Canada at present there is a serious shortage of low-phosphorus pig-iron. If none were available it would be necessary to turn acid open-hearth furnaces into basic; also a much smaller capital expenditure is required for a given net return. W. R. C.

846. *Current-transformer Ratio and Phase Error.* **H. S. Baker.** (Am. I.E.E., Proc. 37. pp. 1173–1183, Sept., 1918. El. Rev., Chicago, 73. pp. 766–769, Nov. 16, 1918.)—In the method of testing described, a special current-transformer or test ring is connected with its primary and secondary respectively in series with the primary and secondary of the current-transformer under test. The number of turns in the secondary of the special current-transformer is varied until the primary and secondary ampere-turns of the test ring are equal to each other. The ratio of turns in the special current-transformer is then the current ratio of the transformer under test. The primary and secondary amp.-turns can never actually balance because they are not exactly in step or opposition; the balance point may, however, be taken as that at which the vector difference between them is at right angles to one of them. The actual minimum value of vector difference gives a measure of the phase-difference between primary and reversed secondary amperes.

Fig. 1 shows the test applied to a current-transformer operating under

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normal running conditions and feeding its actual secondary circuits (*e.g.* ammeters, wattmeters, etc.). A loop LP in series with the primary of the

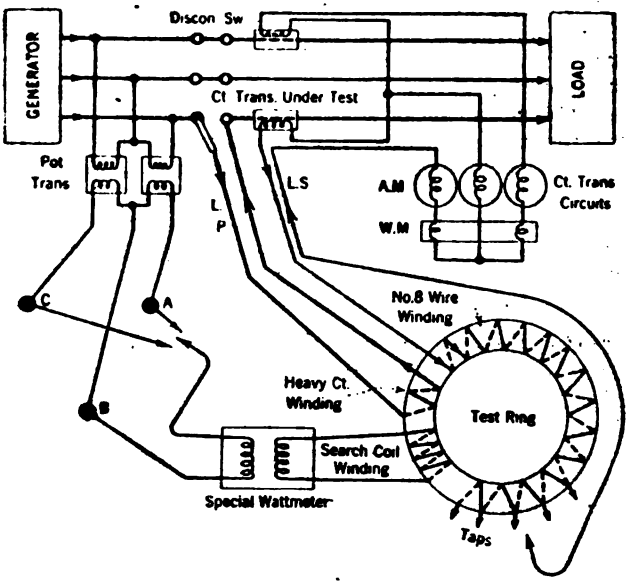

FIG. 1.

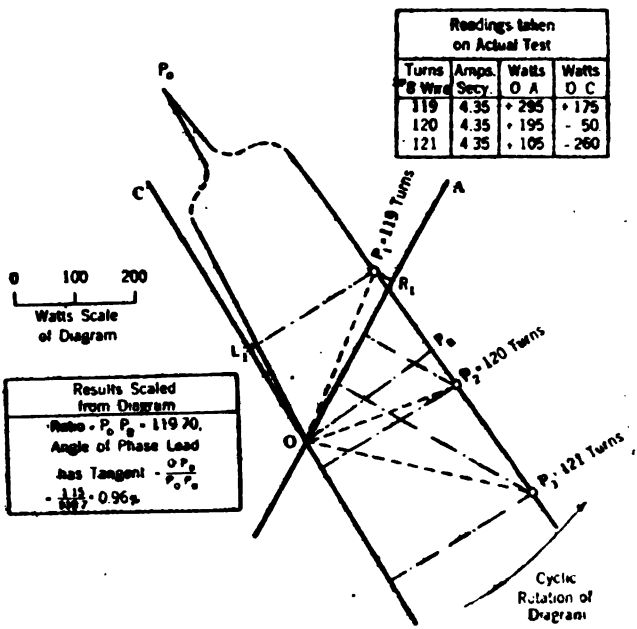

FIG. 2.

current transformers under test feeds a heavy-current, well-insulated winding on the test ring. The latter is of laminated iron and carries three windings, namely, a heavy-current winding of 1, 2, or 4 turns (according to series or

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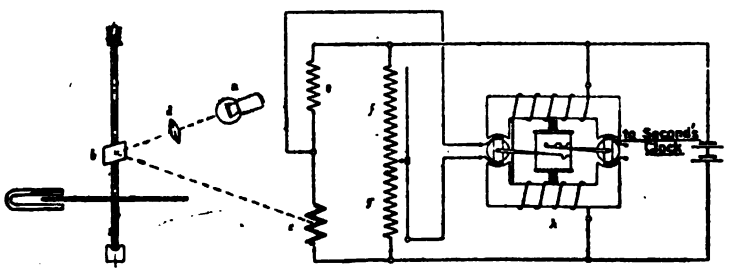
parallel connection); a winding of No. 8 wire in which any number of turns from 1 to 280 may be used; a search-coil winding feeding the moving coil of a special wattmeter. The No. 8 wire coil is in the secondary loop LS where the current opposes that in the heavy winding. In an example cited, the transformer under test was marked 120 to 1; hence a single-turn connection of heavy-current coil and a No. 8 winding of 119 to 121 turns were selected. With the 119-turn setting, readings of + 295 and + 175 were obtained on the special wattmeter when energised from AB and CB respectively. These readings determine the phase and value of the search-coil current and form a measure of the vector difference between amp.-turns in the heavy and No. 8 windings. In Fig. 2, AOC is set out = 60°; + 295 is measured along AO to R_1 and the perpendicular R_1P_1 is drawn; + 175 is then measured along OC to L_1 and L_1P_1 is drawn perpendicularly, thus determining P_1. The vector OP_1 represents the amps. in the search coil. Similarly P_2 and P_3 are determined for 120 and 121 turns in the No. 8 coil. The readings may be considered consistent if P_1, P_2, P_3 are nearly collinear. Dropping OP_B perpendicular to this line, P_0P_B scales 119·7, which is the current ratio of the transformer under test. The tangent of the angle of phase lead of the transformer tested is $OP_B/P_BP_0 = 0{\cdot}96$ %. The complete set of readings, plotting and calculation occupies about 7 minutes. Laboratory methods are discussed in the original. Comparisons between Bureau of Standards tests and the present method show differences of 0·07 % or less in ratio values, and of 4 minutes in phase angle for points at 2 amps. or over. R. E. N.

847. *New Method of Meter Calibration.* **H. Gewecke** and **W. v. Krukowski.** (Elekt. Zeits. 89. pp. 356–357, Sept. 5, 1918.)—A new means is described for recording accurately the angular speed of rotating parts without affecting this speed in any way. The method offers *inter alia* an accurate means of calibrating motor meters.



The accuracy obtainable in meter tests depends primarily on the accuracy with which the time for a given number of revolutions can be determined, since there is no difficulty in measuring the corresponding load to a high degree of accuracy. An error of 0·2 sec. due to unreliability of stop-watch and personal error corresponds to 0·8 % on a 60-sec. test. Stop-watch errors may be avoided by Marel's method, using two pen chronographs, one being actuated by a seconds pendulum and the other by a key which the observer depresses at each revolution of the meter. The personal element still remains.

The spark-recording method proposed by G. Thompson in 1918 has several disadvantages which are absent in the authors' method, illustrated in the Fig. The authors' arrangement uses a ray of light as transmitting medium

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between a mirror on the meter spindle and a selenium cell or bolometer. This method is convenient and cannot influence the meter speed in any way; the meter casing may be closed during the test, and this is frequently an important factor. Light from the lamp *a* is focused by the lens *d* on the mirror *b*, and the selenium cell *c* is illuminated once per spindle revolution by the reflected ray. This cell forms one branch of a Wheatstone bridge, the other arms of which are *e*, *f*, *g*. A battery is connected across one axis of the bridge and a recording chronograph across the other. The second element is connected to a seconds' pendulum. The chronograph is used without relays and a deflection is obtained once a second on one line and once per meter revolution (*i.e.* each time the selenium cell is illuminated) on the other line. The bridge circuit offers the advantage that the current corresponding to the dark-resistance of the cell can be compensated. The sensitivity of the chronograph is considerably greater when the current varies from nil than if the same current variation occurs in a current which is large compared with the variation. Where this counting system is employed, the observer can concentrate his whole attention on maintaining constant load; a test period of 20 or 80 secs is sufficient. It is easy to read the time for any number of revolutions to within 0·01 sec., *i.e.* to determine time accurate to 0·1 % on a period of 10 secs. R. E. N.

848. *Graphical Determination of 8-phase Power Factor.* **E. Haidegger.** (Elekt. Zeits. 89. pp. 885–887, Aug. 22, 1918.)—Assuming symmetrical loading in a symmetrical 8-phase system, the power $= \sqrt{(8)}IE \cos \phi$, and if the two-wattmeter method of measuring power be employed, using instruments with equal constants, then $\tan \phi = \sqrt{(8)}(a_2 - a_1)/(a_2 + a_1)$; where $a_1 a_2$ are the

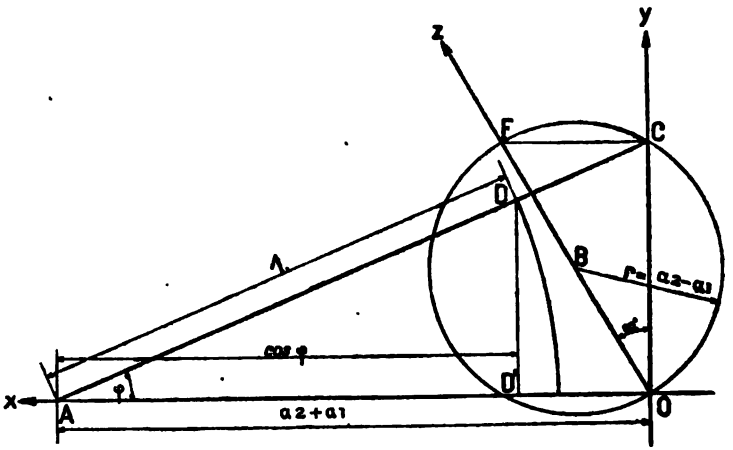

FIG. 1.

deflections of the wattmeters. A convenient graphical construction for $\cos \phi$ is shown in Fig. 1. Between axes CX, OY of rectangular coordinates, draw OZ at 80° to OY. Set out to scale $OA = (a_2 + a_1)$ and $OB = (a_2 - a_1)$. With centre B and radius $(a_2 - a_1)$ draw a circle cutting OY in C. Join CA, then the angle $CAO = \phi$. Set out $AD = 1$ and drop the perpendicular DD', then $AD' = \cos \phi$. The author gives a proof for this construction and shows its application to the case of load tests on 8-phase generators when the total load

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$(\alpha_2 + \alpha_1)$ is constant and the power factor is variable. A chart shows $\cos\phi$ as a function of $(\alpha_2 - \alpha_1)$ for various values of $(\alpha_2 + \alpha_1)$. For practical purposes the curve in Fig. 2 between $\cos\phi$ and α_1/α_2 is more convenient. It should be

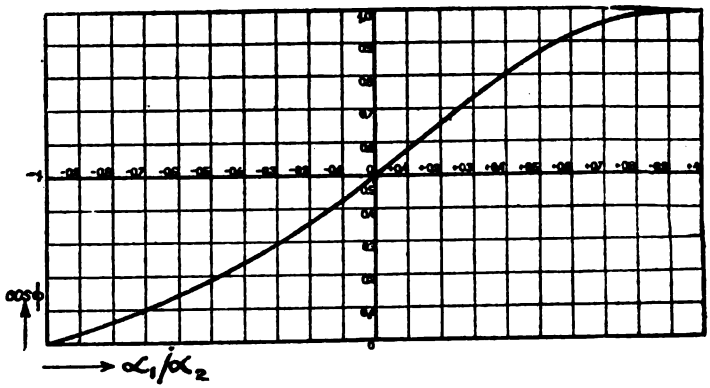
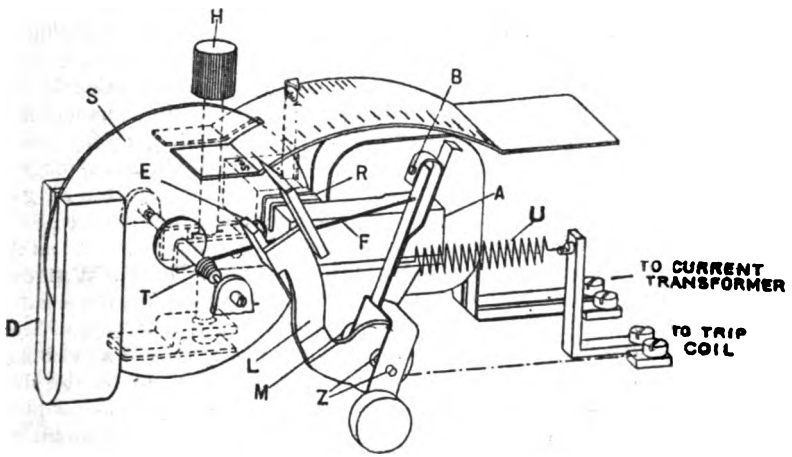


FIG. 2.

noted that this curve is not symmetrical. The construction shown in Fig. 1 leads to more accurate results, but is applicable only when the phase currents and voltages are balanced. R. E. N.

849. *New Maximum-current Time Relay.* K. Trott. (Elektrot. u. Maschinenbau, 86. p. 280, June 16, 1918.)—A new maximum cut-out with inverse time element is described. The makers are Siemens and Halske. (Berlin). Referring to the Fig., an a.c. magnet with shaded poles drives an



Al disc S which is damped by the braking magnet D. A cord F is thus wound on to the drum T and the spring U is extended. The drum T is tapered in the same proportion as the force required to stretch U increases; hence, instead of a balance being reached quickly for any value of current between the torque on the disc and the pull of the spring, the disc continues to rotate steadily as long as the current is maintained. When the contact B reaches the contact E the trip circuit of the automatic circuit-breaker is closed. Independent adjustments are provided for the current and time elements.

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The time element is adjusted by rotating the arm L (carrying contact E) round the spindle Z. The scale of seconds is uniform and may range from 2 to 15 secs. or from 5 to 40 secs. The current setting is effected over a range of 1 : 2·5 (normal 4 to 10 amps.) by swinging the magnet A round the pivot M, by means of the screw H. The adjustments may be made without opening the relay circuits. The relay contacts are capable of interrupting 150 volt-amps., max. current 8 amps., max. pressure 220 volts d.c. or a.c. The relay operates in the times shown on the seconds' scale when the current reaches the value shown on the ampere scale. On heavier overload, the relay operates more rapidly, the law being roughly quadratic in the case of a 2- to 15-sec. relay. The heaviest short-circuit will not, however, operate the relay in less than $\frac{3}{4}$ to 1 sec. (when set to 15 secs. on the time scale) unless an instantaneous release is added to operate at a predetermined overload. Where several relays are connected in series for the selective protection of parts of the network, the relays should have a 5 to 40 secs. scale. When set to 6 amps. and 40 secs. the relay should operate 40 secs. after the incidence of a short-circuit (5 times normal current). R. E. N.

850. *The Technics of Magneto-Magnets.* **E. H. Crapper.** (Engineering, 106. pp. 361–363, Oct. 4, 1918.)—Starting from elementary principles, the author deduces Frölich's law, namely: $1/\mu = a + bH$, where $a = 1/kB_s$ and $b = 1/B_s$. (B_s being saturation flux density, and k the permeability for unit deficit of the flux density from saturation value). This law fails at high densities, but, following Kennelly, B may be divided into ferric inductivity B_i, and ether inductivity B_e; taking the ferric reluctivity r_i separately, $r_i = H/B_i = a + bH$ is exact for pure metals and all ranges. Values for a and b for various steels are given. a represents the magnetic hardness, and is dependent on the elasticity. In permanent magnets the coefficient of retentivity, that is, the ratio of permanent to max. flux, as well as the magnetic rigidity, *i.e.* the intercept on B-axis of the tangent on curve at the point of remanance, are both important; but the author suggests, as a better criterion, the value of the "apparent coefficient of retentivity" defined as the ratio of the remanent flux after $H = -30$ to that before the application of the demagnetising force. The author explains how to determine the dimensions of a permanent magnet which will give a definite flux in a given air-gap. To increase the air-gap flux p %, the length and section of the magnet must each be increased p %. For permanence, Hookham's empirical formula is $A_s/l_s = 70A_g/l_g$, A_s and A_g being magnet and air-gap areas, l_s and l_g their lengths. **E. D. Watson.** (Engineering, 106. p. 568, Nov. 15, 1918.)—Watson emphasises the importance of the subject, and claims that: Crapper's linear equation does not hold below about $H = 100$; the demagnetising curve can be expressed as a similar linear equation; and that Crapper's values of $B_{max.}$ appear to be the flux density in the magnet when subjected to $H = 400$, an arbitrary figure adopted in the magnet industry. He questions whether the ratio of apparent to actual coefficient of retentivity is of value. In magnetos, there is varying reluctance in addition to opposing magnetomotive forces, and the extent to which the magnet can recover in the intervals is of importance, but data on this seem to be lacking. H. F. H.

851. *Experimental Investigation of Porcelain Mixes.* **G. I. Gilchrest** and **T. A. Klinefelter.** (Elect. J. 15. pp. 77–81, March, 1918.)—The ideal insulating material is that possessing high insulation (strength and resistance), high mechanical strength and high resistance to temperature changes. The

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investigation was to determine the limitations in the porcelain mixes of these qualities; to determine what should be sacrificed in one quality to allow a high percentage in another. What materials were to give the maximum results throughout the practical range of electrical porcelain was the scope of the research.

The tests were carried out on a cup having 8/16 in. thickness in the base and a greater thickness in the sloping walls; a height of 2¼ in. and a diam. (the greatest) at the top of 3⅛ in. The range covered from low felspar to high, no flint to high flint, low to high clay content. Triaxial figures are given in the paper with the results plotted for the following: Zones of mixes of commercial wares and for investigation; ease of working; degrees of translucency; variations of colour; appearance of fracture; specific gravity; shrinkage; dielectric strength; resistance to mechanical blows; resistance to local heat.

A final triaxial figure is shown giving the areas of the maximum value of the three main properties (enunciated at the beginning of abstract). High dielectric strength appears to be characteristic of high felspar content; high mechanical strength, of high flint content; high resistance to local heating, of a high clay content. A maximum of the properties by choosing the correct proportions can thus be secured. J. L. I.

852. *Characteristics of Iron and Steel Conductors.* **C. E. Oakes** and **P. A. B. Sahm.** (El. World, 72. pp. 150–151, July 27, and pp. 249–252, Aug. 10, 1918.)—This article is a symposium of what has been found by experience concerning the electrical characteristics of iron or steel wire or cable, together with many new tables of mechanical data. The resistance of a conductor carrying a.c. is affected by the frequency and by the magnetic properties of the conductor. The "effective resistance" (that which, when multiplied by the square of the current, gives the power loss in the line) is a function of frequency, permeability, hysteresis and eddy current; and its value between specified current limits may be expressed by $R = a + Ib$. Values of a, b for various currents and various sizes of wire are given in the original. Tables are given of internal inductive reactance of single conductor; of external inductive reactance for various wire sizes and spacings; and of charging current: 60-cycle supply is assumed in each case. Cheap construction is generally a very important consideration where iron or steel wires are used; the wire-stringing tables given by the authors are based on extreme weather conditions, but a method is given by which the sag or tension for lower factor of safety may be calculated. Recommendations are made concerning the sag to be given in various cases. The possibility that copper lines may subsequently be installed in place of iron should be borne in mind. R. E. N.

853. *Magnetos for Oil Engines.* **E. Biffi.** (Elettrotecnica, 5. pp. 302–306, Aug. 5; 326–332, Aug. 25; 386–392, Oct. 5, and pp. 407–411, Oct. 15, 1918.)—A large number of experiments upon a Bosch magneto are reported in this article. The type experimented was that for an 8-cylinder oil engine with fixed coils and rotating magnetic armature core. The two functions of a magneto, as generator and as transformer, are separately considered and of the latter the theory is given. The magnetic flux curves, the characteristic curves with open secondary or with the magneto working normally, the curves of the current through the break and those of the current through the condenser, etc., were obtained. The max. induction in the core was

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found to be of 9700 c.g.s. lines per cm.^{2}. A large number of diagrams and curves illustrate the article. E. B.

854. *Investigation of Heating of Conductors.* I and II. **H. C. Horstman** and **V. Tousley.** (El. World, 72. pp. 489–490, Sept. 14, and pp. 690–693, Oct. 12, 1918.)—Experimental data gathered by the authors indicate that the National Electrical Code might be made less rigid, especially in the case of intermittent or short-period loads. The steady current which will produce a given final temperature-rise in a conductor can be found from the formula $I = \sqrt{KC}$, in which K is a constant and C the temperature-rise above the surrounding air in deg. C. The constants for the various wire sizes here considered are deduced from heat curves obtained experimentally in the laboratory of the Commonwealth Edison Co. of Chicago, where the tests were made at the suggestion of the Department of Gas and Electricity of that city. The constants are obtained by dividing the square of the current used by the rise of temperature produced in the conductor. The tests were carried out on cables looped three times through a 10-ft. length of duct supported in air on wooden horses. The copper temperature was obtained by means of thermo-couples in contact with the core at the centre of the conduit. Two tables are given, one showing the constants and the second giving the carrying capacity calculated according to the formula for rubber-covered conductors.

As regards intermittent loads, the ultimate temperature-rise of a conductor depends upon the ratio of the "on" and "off" time of the current; unless the current is off long enough for all the heat produced in the "on" period to be dissipated, the temperature of the cable will continue to rise. At low temperatures heat is dissipated very slowly, but at higher temperatures (20°–30° C.) much more rapidly. This is shown in Tables III–XVIII, for wires ranging from size No. 14 (B. and S.) to 500,000 circ. mils. Each table gives the time in seconds required by the various currents to raise the temperature of the conductor 2 deg. C. within given ranges of temperature. The time required to lose 2 deg. C. either on a small direct current or no current is also given. Table III may serve as an example:—

TABLE III.

THREE NO. 14 D. B. R. C. WIRES IN ½-IN. BLACK-ENAMELLED CONDUIT.

Temperature Range.	Heating Load, Amps.				Cooling Load.	
	15.	20.	25.	45.	7½.	0.
10–12°	690	120	60	12	330	180
12–14	1200	130	65	12	250	135
14–16	2400	180	70	12	180	120
16–18	—	240	75	12	135	105
18–20	—	300	80	12	120	90
20–22	—	420	90	12	105	75
22–24	—	570	100	12	85	60
24–26	—	1500	110	12	75	60
26–28	—	—	125	12	60	55

Thus for a No. 14 wire, 20 amps. will raise the temperature of the conductor from 10° C. to 12° C. in 120 secs., but it will require 420 secs. to

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raise it from 20° C. to 22° C. Though only 120 secs. are required for a current of 20 amps. to raise the temperature 2 deg. C. from 10° to 12° C., yet it takes 180 secs. to dissipate this heat. It will require 180 secs. to rise from 12° to 14° C. and the dissipation will be accomplished in 185 secs. With 20 amps. "on" and "off" for equal lengths of time there will therefore be a continuous rise until a trifle over 14° C. has been reached. The same table shows that if a current of 45 amps. exists for 12 secs. and the temperature is not required to go above 16°, an off period of 120 secs. must be allowed.

Only current values actually used in the tests have been considered. Calculations for other currents may be made by means of the formula $t = T \times 2 \times k/I^2$, where t is the time in secs. required to produce a temperature rise of 2 deg., T is a length of time in seconds so short that the heating curves plotted within its limits may be regarded as straight lines, k a constant equal to I^2/C; I being any convenient current and C the temperature-rise caused by that current within the given time limits. The formula should only be used for heavy overloads lasting a short time.

The usefulness of these tables is based on the assumption that no attention need be paid to the heating of a conductor till it approaches the limits imposed by operating conditions. V. C.

855. *Percentage Error.* **A. Russell.** (Faraday House J., Michaelmas Term, 1918. El. Rev. 88. pp. 840–841, Oct. 11, 1918. Abstract.)—The author considers that the percentage error method of stating the accuracy of instruments is misleading unless the error is quite small. If R be the true reading, R^1 the observed reading, and e the percentage error referred to R, then $e = 100(R - R^1)/R$ low, if R^1 be less than R; and $e = 100(R^1 - R)/R$ high, if R^1 be greater than R. On this basis, if a reading of 1 ft. be given instead of 1 in., $e = 1100$ %; but if a reading of 1 in. be given instead of 1 ft., $e = 92$ %. In other words, if the percentage error be high its numerical value has a different meaning when in excess than when in defect. So long as the percentage error does not exceed 5, the number gives a fairly good index to the accuracy of the instrument whether the error be positive or negative. If the percentage error be referred to the observed reading R^1 then $e' = 100(R - R^1)/R^1$ low; or $100(R^1 - R)/R^1$ high. Even if e' be as high as 5, the error introduced by using these equations instead of those for e is less than 8 in 1000. If, however, e' be large, the results are quite irrational. The table compares values of e and e' for various observed readings R^1 and a true reading $R = 100$:—

Observed R^1 (Low).	e %	e' %	Observed R^1 (High).	e %	e' %
100	0	0	100	0	0
80	20	25	120	20	16·7
60	40	66·7	140	40	28·6
40	60	150	160	60	37·5
20	80	400	180	80	44·4
0	100	Infinite	200	100	50
—	—	—	1000	900	90
—	—	—	10,000	9900	99

It is recommended that the percentage method be not used at all. In the case of meters it is sufficient to measure the ratio n of the true rate to the

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actual rate. Then the true rate reading or bill = n times the actual rate, observed reading or apparent bill. This method is simple and easily intelligible. R. E. N.

856. *Electric Welding Developments.* **H. A. Hornor.** (Am. I.E.E., Proc. 37. pp. 1185–1195, Oct., 1918. El. Rev. 83. pp. 555–557, Dec. 6, 1918.)—The author reviews recent progress in electric welding in the United States. In spot-welding, after testing the method on ½-in. and ¾-in. steel plates, an experiment was made on three 1-in. plates, which was quite successful. As a result a large spot-welder, having a 5-ft. gap, will be employed in welding a 40-ft. section of a standard 9600-ton ship at Kearney, N.J. In arc-welding an investigation of sample welds in ½-in. structural steel, made at about 14 different places and under widely varying conditions, has been carried out, and showed a remarkable similarity. Practically all the welds broke at over 50,000 lbs. per sq. in., and several at over 60,000 lbs., the average being about 58,000 lbs. In the bending test one sample was bent to an angle of 78° before a crack started, and final failure occurred at 80°. Three 12-ft. cube electrically welded tanks are being constructed for testing purposes, so built that 12 to 15 different types of joint are employed. These will be subjected to a static strain and afterwards tested by external shock and crushed to destruction.

The relative advantages of bare and covered electrodes have not yet been settled, but it is mentioned that in the above tests the best sample was made with a coated (not an asbestos-covered) electrode, using alternating current. It would seem that the bare electrode does not make so ductile a weld, or at least, one so easily bent, as the coated electrode. The reliability of a weld depends mainly upon the skill and experience of the operator. Automatic machines are being developed for repetition work, but will not entirely displace the skilled workman. The average apparatus requires about 6 to 8 kw. per welder, but in low-voltage outfits the consumption is only 8½ kw. or less.

As an instance of the saving to be effected by electric welding, Adams states that at one shipyard the total number of parts to be welded in a standard ship amounted to 225,000. The labour cost for riveting these would be about $245,000, and for welding about $99,000, a saving of $146,000. In other instances the saving is as great as 90 %. R. J. W.-J.

857. *Electric Welding in Ship Construction.* (El. Rev., Chicago, 73. p. 495, Sept. 28, 1918.)—The first steel vessel constructed entirely without rivets was recently launched in England, and has since been in service with full cargo during exceptionally rough weather, with most satisfactory results. The object of this experiment was to prove the ability of welded construction to withstand the strains peculiar to a ship at sea. It is not proposed altogether to dispense with riveting, which in certain sections is cheaper and quicker than welding. In order to utilise material already available on site the welded barge is similar in all respects to the standard riveted type with lapped joints, except that the hull plates were arranged for clinker build and the plate edges joggled to permit horizontal downward welding so as to reduce the amount of overhead work, which is more difficult of execution. The vessel to be welded was 125 ft. between perpendiculars and 16-ft. beam, with a displacement of 275 tons. The hull was rectangular in section amidships, with only the bilge plates curved. It was built up of 71 transverse frames and contained three bulkheads, those fitted fore and aft being watertight and the one amidships non-watertight. The shell plating was ¼ in. and 5/16 in. All joints were lapped

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in the manner described. When the operators had become accustomed to the work—a matter of a few days—the speed and quality of the work were excellent. For the overhead work special electrodes were employed, which justified the slightly increased cost. All watertight joints up to and including the underside of bilge plates were continuously welded both inside and outside, the other watertight joints being welded continuously on one side and tack-welded on the other. On the shell plating the continuous welding was on the outside in all cases. For internal non-watertight joints and frame construction tack-welding was adopted, the length of welding being carefully calculated to give a margin of strength over a similar riveted joint. The average speed of working at the commencement was 4 ft. per hr. and towards the end 7 ft. per hr. The saving in labour was 245 man-hrs., and owing to the absence of rivets over 1000 lbs. of metal was saved. These results will be improved upon when the design is modified to suit electrically welded ship construction. The total cost of welding was as under :—

Electrodes, $865 ; Electric current, $297 ; Men's time, $306 : Total, $1468.

It is anticipated that the cost of electrodes will be reduced at least 60 % in the future. It will then be possible to build a vessel of 275 tons with an estimated saving of from 25 to 40 % of time and about 10 % of material. As a result of the demonstration a new design of barge has been prepared in which it is proposed to incorporate both electric welding and riveted construction. R. J. W.-J.

858. *Electric Arc-welding Apparatus.* **W. L. Merrill.** (Eng. Club Phil., J. 35. pp. 436–439, Sept., 1918.)—Successful welding can be done with both alternating and direct current, and both systems have their advantages, the choice of either depending upon local conditions. The low voltage used for welding—12 to 15 volts on direct, and 20 to 30 volts on alternating current—raises a problem in determining the best method of distribution, *e.g.* in ship-welding. In one large yard the system proposed is to instal four motor-generators working off the 2200 volt, 60-cycle supply, each set having an output equal to one-fourth of the total current required for 60 welders, at an e.m.f. of 60 volts, a resistance being used to reduce that voltage wherever the welders happen to be working. Another system that can be used requires 125 volts, d.c., in which case the 2200 volts, a.c., would have to be transformed by means of a separate motor-generator for each welder. Alternatively the 2200-volt a.c. supply could be reduced to, say, 440 volts by a static transformer, the motor-generators being worked at the latter voltage. A further alternative provides for the e.m.f. to be reduced to 110–125 volts, a.c., and using this directly through a resistance or reactance. Owing to some peculiarity in striking the arc it is necessary to start with at least 110 volts in the case of a.c., while with d.c. 40 to 60 volts is sufficient.

Spot-welding has been used for many years for welding thin plates up to ¼-in. thick, but recently it has been found possible to weld as many as three 1-in. plates by this means. R. J. W.-J.

859. *Electric Arc-welding.* **A. M. Candy.** (Am. I.E.E., Proc. 37. pp. 1159–1171, Sept., 1918. El. Rev. 83. pp. 414–415, Nov. 1, and pp. 455–456, Nov. 8, 1918.)—Gives a general description of the carbon and metallic arc-welding process and its principal applications. Examples of the latter are illustrated and particulars given of apparatus used in carrying out the work. R. J. W.-J.

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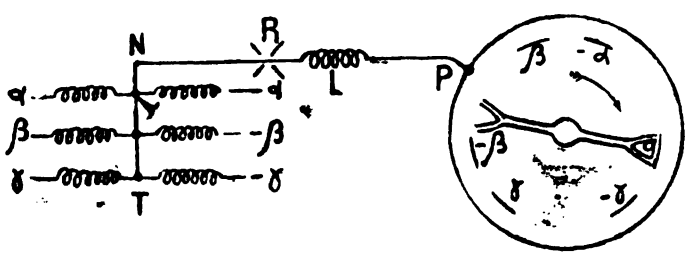
GENERATORS, MOTORS AND TRANSFORMERS.

860. *Economical Loading of Transformer Banks.* (El. World, 72. pp. 787–788, Oct. 19, 1918.)—Total loss curves are given for 8-phase transformers carrying various loads at various power factors, and it is shown that it is not always most economical to load one transformer fully before switching in the next one. An additional transformer increases the core loss but may more than compensate for this by the reduction effected in variable or copper losses. The economical point at which to add a second transformer bank is at practically the same kv.a. load, regardless of power factor; *i.e.* at a lower kw. load, the lower the power factor. This switching point is at a constant value of loss regardless of power factor, namely, that at which the total loss in one transformer is 8 times the core loss in one transformer. It is proved that "the economical point is that at which the core loss in a single transformer equals half the copper loss in that transformer or one-third of the total loss." Similarly when n units are in service, it is most economical to switch in the $(n + 1)$th unit, when the core losses per transformer equal $(n/n + 1)$ times the copper loss of one transformer. The above results must be modified before applying them to groups of dissimilar generators, transformers or other apparatus. R. E. N.

861. *A Converter of 3-phase into Direct Current.* **O. M. Corbino.** (Elettrotecnica, 5. pp. 392–394, Oct. 5, 1918.)—This apparatus is an adaptation of the mercury-jet break in an inert gas, widely used for induction coils. The fixed plates of the new apparatus, 3 or 6 in number, are connected to the terminals of the star-connected secondary windings of an ordinary 3-phase or a special transformer, as shown in the Fig. The metallic vessel of the break is connected to the mid-point of the secondary just alluded to. In the connecting wire from the vessel P to the centre (N) of the star a practically direct current is generated with the help of a self-induction L. A synchronous motor making one turn in two periods rotates the break. The mercury-jets are two diametrically opposite or four, projected from two small forks also diametrically opposite, as shown in the Fig. The fixed plates $\alpha, -\alpha, \beta, -\beta, \gamma, -\gamma$



shown in the Fig. must be imagined as connected to the terminals of the transformer indicated by the same letters. The dimensions of the plates and of the mercury-jets are so calculated as to prevent a plate being abandoned by the jet before the following plate is in contact with it. In this manner two plates are for a moment short-circuited through the mercury: but as this takes place at the instants when the potentials of these plates are equal, this short-circuit not only has no bad consequences but, on the contrary, is favourable to the continuity of the direct current.

The power obtained can be as high as 10 kw. and the efficiency as high as 97 %. E. B.

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ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

862. *Compensation of Voltage Losses in 3-phase Lines.* **E. Piernet.** (Rev. Gén. d'El. 4. pp. 540–544, Oct. 12, 1918.)—Owing to the war, many 3-phase plants are obliged to furnish more power than that for which they were calculated. It follows that voltage losses in the lines become so important that utilising apparatus can no longer work.

There are two means of remedying this situation, namely: (1) To increase the power factor of the installation, and (2) to install booster transformers in order to compensate the voltage fall.

In the first case, if an installation furnishes a power P under power factors of 0·9, 0·8, 0·7, 0·6, 0·5, it will be possible to increase the powers respectively by 11, 25, 48, 67, 100 %, bringing the power factor to unity and maintaining the same pressure at the end of the line. The reactive powers that the synchronous motors or the like are bound to furnish will be respectively 0·484, 0·749, 1·018, 1·333, 1·732 of P. This method is not always applicable, either because of the difficulty of finding at the moment the synchronous motors, or because the increase of the power can be insufficient. Induction regulators could be utilised to compensate the voltage fall, but not only cannot they be obtained quickly, but, moreover, they cannot be employed if the voltage drop is larger than 15 or 20 %. A booster transformer is a transformer one winding of which is in parallel with the line and the other is in series with it. It gives, therefore, a constant voltage increase. It will then be necessary to switch it in the line only when the voltage drop begins to become so important that the apparatus begins to work badly. The author demonstrates that it is preferable to insert the booster transformers after the step-up transformers.

The use of the booster transformers is not a good solution, as the efficiency of the installation is rendered bad, but it is a solution which can be rapidly realised; it is a war solution. A practical example is given in the article.

E. B.

863. *Neutral Point on a Delta-connected Set of Three-phase Transformers.* **E. E. Stark.** (New Zealand J. of Sci. 1. pp. 217–218, July, 1918.)—This describes a scheme of obtaining an artificial neutral on a 3-phase system with a delta method of lighting distribution by using a star-wound induction motor and earthing its neutral. The regulation of the system will be governed by the capacity of the motor, which transfers energy from one phase to the other.

W. H. S.

864. *Size and Working Cost of Machines for D.C. Transformation.* **T. Carter.** (Electrician, 81. pp. 492–494, Oct. 11, and pp. 514–516, Oct. 18, 1918.)—The usual practice, where direct current is required at a voltage different from that of the general supply, is to employ a motor-generator to deal with the transformation. A plain motor-generator scheme (1) may be used to deal with the whole power to be transformed; or the booster (2) or balancer (3) principle may be employed. In both of the latter cases, one of a pair of machines is in series with one of the mains of the general system, whilst the

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other is connected across the mains; the only difference between the cases is that in one, the machine across the mains is nearer to (instead of further from) the supply than is the machine in series with the main.

The author considers the difference existing between these three arrangements and arrives at expressions for the relative sizes of the machines required, which are plotted in curves based on an assumed efficiency of 100 %. Conclusions are drawn from these expressions, and curves regarding the first cost of the machines and their method of operation. Corrections are then introduced to allow for the actual efficiency of the machines and curves of overall efficiency of transformation are deduced, showing that the cheapest set to buy is also the cheapest set to run. Finally, a comparison is made between a machine with double-wound armature and a motor-generator as regards voltage regulation; principles are set out for the treatment of certain well-known schemes for variable-speed motors.

Unless there is some special reason (such as electrical independence) for the use of a plain motor-generator, either the booster or balancer arrangement should be used, since the amount of machinery required is then less. In order to produce a voltage $= r \times$ supply voltage, the balancer arrangement (3) is cheapest if $r<1$; and the booster scheme (2) is cheapest if $r>1$. From the point of view of overall efficiency, scheme (3) is best so long as $r<1$, and scheme (2) is best when $r>1$. Let C be the current taken from the mains at voltage V in order to yield C^1 amps. at V^1, then in the case of the ordinary rotary balancer for a d.c. 3-wire system: $VC = 2V^1C^1/(1+\eta\eta')$; where η,η' are the efficiencies of the two machines. This result shows that whilst a low value of $\eta\eta'$ in a rotary balancer leads to reduction in the size of machines required, it leads also to an increase in the running cost of the whole scheme and is therefore to be avoided. When only one value of V^1 is required, a single machine with double-wound armature may be employed. The only disadvantage of this is that the machine has not a fixed ratio of terminal voltages, owing to the internal voltage drop. The voltage on the generator side decreases as the load increases, *i.e.* the ratio $r = V^1/V$ is not constant. A motor-generator, on the other hand, can be compounded to yield constant r.

R. E. N.

865. *Balanced Protection by Split-conductor Cables.* **W. H. Cole.** (Am. I. E. E., Proc. 37. pp. 798–820, July, 1918.)—This paper is intended to embody the experience of the Edison Co., of Boston, in the design and application of selective balanced-protection schemes to parallel-connected transmission conductors. Split-conductor cables can be designed in various forms, but the concentric twin cable is probably the simplest and most convenient. The author describes special apparatus to be used in connection with current-balancing schemes, and the simple differential transformer is undoubtedly the best device for the purpose so far suggested. A schedule of installations in the Boston system is included in order to give an insight into the extent of the work: there is also a description of the results obtained in actual operation. No general conclusions are drawn, as the paper describes rather the progress that has been made in the particular case under consideration: conclusions are, however, drawn in cases where the evidence seems to be conclusive. An appendix contains a mathematical discussion by C. A. Adams of a number of reactive end-impedance devices. W. H. S.

866. *Calculation of Poles for Electric Lines.* **E. Lo Cigno.** (Elettrotecnica, 5. pp. 402–407, Oct. 15, 1918.)—The author calculates the weights

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of different types of poles and analytically draws out the conditions for the minimum, the variables being the inclination α of the diagonals and the distance B between the centres of gravity of the sections of the almost vertical irons. Diagrams in Cartesian coordinates allow of obtaining immediately the values of B and α when the moment M and cutting force T acting at the base of the pole are given. The diagrams hold both for square-sectioned and for rectangular-sectioned poles. Numerical examples are given. E. B.

867. *Swiss Report on Corrosion by Earth Currents of Electric Railways.* (Schweiz. Elektrot. Verein., Bull. 9. pp. 157–167, Aug., 1918. First Report of the Joint Committee of the Swiss Gas and Water Inst., the Inst. of Swiss Secondary Railways, and the Swiss Electrot. Inst.)—This is the second part of the report [for the first part see Abs. 667 (1918)], and deals chiefly with the form and size of the corrosion phenomena met with in practice, and their causes.

Corrosion may be due to two causes, either chemical or electrical. The former is first considered. Rust, in the narrow sense, is defined as the red oxide of iron formed by the action of air and water; but in a wider sense it may be taken as including insoluble basic salts of iron formed by the action of acids in the soil. Wrought-iron pipes seem to be destroyed more readily than cast-iron by rust in the narrow sense, though this may be due to the fact that large cast-iron pipes are often laid deeper and hence further from the oxygen of the air. But where it is a question of acids, cast-iron is more readily destroyed than wrought; soils containing calcium and magnesium sulphate or cinders are especially dangerous.

Electrochemical action may be serious, especially where iron is in contact with metals higher in the potential series. This galvanic action may also occur between cast and converter iron, but does not as a rule constitute a serious menace.

Corrosion due to earth currents may be caused by mechanical destruction of insulating coverings, which then become a danger rather than a protection, since the current density may be so high as to cause serious damage in conditions otherwise favourable.

The case of pipes laid parallel to electric rails is considered, as being more amenable to mathematical treatment. In such a case the p.d. between pipe and rail varies from 0·5 to 3 volts for a characteristic operating period; increases up to 5 volts may occur. Besig found values as high as 20 volts, and Pionchon quotes a case where the lead sheath of a telegraph cable showed a pressure drop of 25 volts where it crossed a rail; this does not necessarily mean the pipe will be corroded, as the earth and transition resistances may be high or the traffic on the line small; but it indicates extraordinary leakage from the rails. The resistance of the earth varies according to its composition and moisture content; but mortar and cement have a much higher conductivity than ordinary soil. A table is quoted giving the current density required to reduce the wall of a pipe to one-half its original thickness in 20, 30, 40 or 50 years.

Considering the pipes, the higher the resistance the less the current that will flow through them. But if the resistance of the joints is high compared to the intermediate portions, the current will tend to shunt the joint, causing corrosion where it enters and leaves the pipe. Insulating jointing pieces may be used, but should be near together; this method is no use, however, for pipes already laid. Happer went thoroughly into the question of pro-

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tection by means of insulating joints and coverings, investigating the influence of inorganic joints, alloys, oxides, silicates and wrappings of paper, cloth, cement, etc., and found none of them could be relied on with certainty. Screwed or riveted joints in wrought iron show no great increase in resistance, but a socket joint is equivalent to 80 metres of pipe.

V. C.

868. *Control and Safety Devices for 3-phase Winding Gear.* **M. Graf.** (Zeits. Vereines Deutsch. Ing. 62. pp. 441–446, July 13, 1918.)—Few winding installations of high or medium power have been equipped with simple 3-phase motors in the past owing to the violent starting of such machines and their poor flexibility. In spite of the advantages of 3-phase motors in other respects, these limitations have led to the use of more costly and complex equipments (Leonard system, 3-phase commutator motors, and double Déri motors). The Gewerkschaft Bernsdorf (of Hildesheim) has had in use for 2½ years past a winding plant driven by two 3-phase induction motors each of 880 h.p. (total overload 1175 h.p.). The equipment is provided with Brown-Boveri automatic safety devices and is said to be the first installation of its kind. The special advantages of the 3-phase induction motor include simple construction, reliability, possibility of direct connection to high-voltage supply, low capital cost, small copper requirements, and easier use of substitute metals. It is impossible to alter the inherent characteristic of the induction motor in respect of the heavy current demanded during starting, but this is a less important factor in modern industrial supply systems. It is impracticable to use a direct-coupled induction motor, but the losses in gearing between motor and winding drum are very small.

The induction motor is incapable of the electrodynamic braking effect, which is so easily secured with the d.c. motor; hitherto the only method of stopping was to switch the motor out of circuit and apply the safety brake. The arrangement used in the present case is illustrated in the original article. A brake operated by compressed air is used both for holding the winding drum and for controlling the set. Electromagnetic valves control the air supply, and exceptionally fine and rapid adjustment is needed in the air circuit. It is arranged that pulling back the control lever applies graduated braking automatically. A single lever is used for both control and braking: full braking can, however, be applied at any moment. The control lever actuates the electromagnetic air valves through a so-called "contact manometer," consisting of an air-tight vessel containing a certain quantity of mercury. The side chamber permits the level of the mercury to vary according to the air pressure; above the mercury are two plunger contacts, the position of which is determined by the position of the main control lever. The circuit controlling the magnet of the exhaust valve is closed first; then the admission valve is opened, admitting compressed air to the brake. The increase in pressure causes the mercury level to descend, the admission valve circuit is broken and the supply of more air is interrupted, but the brake remains applied under a certain pressure. The cycle is repeated when the main control lever is moved further over, and the brake pressure is then increased. Moving the control lever in the opposite direction reverses the action. The air valves may be situated at any distance from the contact manometer and, since the valves are always opened fully if at all, the brake action is practically instantaneous.

It is arranged that the valve magnet circuits can be completed only when the main control lever is moved beyond the neutral position, into the

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braking zone. It is secured that the magnet circuits can be completed only when the control lever is moved to "braking," whichever the direction of motor rotation. Completion of the braking circuit operates a switch which opens in two phases the circuit of a motor operating the main switch; this arrangement prevents the main motor from being started in the opposite direction so long as the brake is on. At low speeds the compressed air braking is cut out of action and electrical braking by reverse current is employed. The centrifugal switch is connected in the valve magnet circuit and closes at about 15 % of the normal speed of the winding motor; it is open, however, when the main motor is stationary or the rope speed low.

After explaining the difficulties and risks hitherto encountered in lowering loads where an induction motor is employed, the author shows how these are overcome by an automatic centrifugal switch which actuates a second switch short-circuiting the leads connected to the rotor slip-rings. Further details and illustrations of this particular installation are given in the original. The winding motor is brought to rest automatically at the end of the travel by the depth indicator operating on the control lever. It is impossible for the motor to race when lowering loads, and it is considered that this equipment is at least equal to any other system in simplicity and reliability. R. E. N.

869. *The "Bayernwerk" Electricity Scheme.* (Elekt. Zeits. 39. pp. 861–863, Sept. 12, 1918.)—In 1915 O. v. Miller drafted a scheme, since developed and now adopted by the Bavarian Government, under which the Bayernwerk is to establish a h.t. network to distribute electrical energy over an area including Munich, Augsburg, Dettingen, Schweinfurt, Nuremberg, Wurzburg, Bamberg, Bayreuth, Amberg, Haidof, Regensburg, Landshut and Kochel. Energy will be collected from the Walchenseewerk, from State water-power stations to be erected from time to time, and from power houses having available surplus energy at economical rates. The Walchensee station is to develop 50,000 kw. and deliver to the network 150 million kw.-hrs. per ann. at 100,000 volts, 3-phase. It is proposed to supply energy only in bulk, to large consumers who will erect their own transformer stations and distribution networks. A list is given in the original paper of firms and municipalities interested in the foundation of the Bayernwerk. The State is to put up 51 % of the 10 million marks capital, and other shareholders the remaining 49 %. The State reserves the right to purchase the entire undertaking after 50 years at a price equal to the first cost minus 1 % per annum.

It is proposed that the network be commenced immediately peace is declared, the conductors being 70 mm.² stranded copper or 120 mm.² stranded Al carried on iron masts with long span. The company is to erect the system in the following stages :—

	Estimated Millions of kw.-hrs. per ann.	Cost, Millions of Marks.	Total Cost, Millions of Marks.
Kochel–Munich–Augsburg–Nuremberg.....	85·0	9·8	9·8
Amberg – Haidof – Regensburg – Landshut – Munich	110·0	6·4	16·2
Nuremberg–Wurzburg–Schweinfurt–Bamburg–Bayreuth–Amberg	140·0	8·8	25·0
Wurzburg–Dettingen	150·0	2·0	27·0

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Bulk consumers are to pay 18 M. per ann. per kw. maximum demand plus 2·6 pf. per kw.-hr., with ± 0·05 pf. per kw.-hr. per 1 M. rise or fall in coal price above or below 86 M.; 10 % discount is allowed to large consumers; the fixed charge is reduced if the dividend exceeds 5 %; and the coal clause is to be revised quinquennially. The mean price for the Bayernwerk will be about 3·2 pf. per kw.-hr.; and the company will pay 1·8–1·2 pf. for h.t. energy from the Walchenseewerk and other hydro-electric stations. The financial prospects and probable output of the company are analysed in detail in the original paper. The main object to be fulfilled is not so much the provision of very cheap energy, as the distribution of energy throughout the country. The general policy of the scheme and its relation to the Walchenseewerk are also discussed at length. R. E. N.

870. *An Interconnecting Transmission Line.* (El. World, 72. pp. 612–618, Sept. 28, 1918.)—Describes the effect of an interconnecting line between the systems of the Edison Electric Co., of Boston, and the New England Power Co. A plan is given showing the areas affected by this alteration, and the positions of the various hydro-electric plants and sub-stations. W. H. S.

871. *Hydraulic Power Supply in France.* (Rev. Gén. d'Él. 4. pp. 549–559, Oct. 12, 1918.)—This is an abstract of an official statement by the French Government of the amount of water power that is available in France. In each case particulars are given as to the amount of water available, and the power which it represents, together with an estimate as to the cost of developing it. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

872. *Control of Tramcar Trains.* R. Wolff. (Elekt. Zeits. 39. pp. 365–367, Sept. 12, 1918.)—The safety system of control described is due to the A.E.G. and has been used for trains of tramcars in Dresden during the past year. The use of from 1 to 3 trailers is common in many cities owing to the density of traffic at certain hours and the scarcity of labour. More powerful motors have become necessary; instead of single motors 11 kw., 1-hour rating, two or four 44-kw. motors may be used and there is serious difficulty in accommodating them. Early tests with several coupled motor-cars controlled from one point led to cumbersome switch, resistance and coupling gear; these defects are overcome by the new equipment, which has been tested on a train of two motor-cars (each with its own trolley pole and two 28-kw. motors) and a plain car between them. The weights of the 3 cars empty and with 142 persons are 38½ and 44 tons respectively. Compressed air brakes are fitted. The track includes severe gradients, and four electrically operated point-setting devices. The motors are controlled on the series-parallel system and provision is made for isolation of a defective motor. Mechanical design of the equipment and the principle on which the resistance sections are utilised, are such that the control gear is light and compact enough to be fitted to any car. The only connection between the driving platforms is the 10-core control cable. Wiring diagrams are given in the original. In the train described, the main air vessel and pump for braking are below the centre car, an auxiliary

[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

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reservoir being placed under the motor-cars. Special insulation is provided where required to allow for the fact that when the front and rear cars span section points of the 3-wire system, there is a p.d. of over 1000 volts between certain conductors. Necessary precautions in operation, particularly when running over the electrically operated points, are noted in the original paper. The experimental train ran 25,000 km. without electrical breakdown or any serious depreciation. Trains of 4 or more cars may be operated on the same principle. Depreciation of control gear is less, and that of motors no higher than in ordinary service. The motors used in the experimental train proved to be unnecessarily powerful, so that no reliable cost data can yet be given. R. E. N.

873. *The Selection of Motors for Traction Purposes.* **C. W. Squier.** (El. Rly. J. 52. pp. 505–508, Sept. 21, 1918.)—This article deals with the choice of a motor for a certain condition of service: this depends on the consideration of a number of curves, which include those showing the relation of schedule speed to the number of stops per mile, the variation of coasting time with free running speed, the relation of coasting time to free running speed, and the characteristics of the various motors concerned. These lead to a further series of curves which show typical runs and the most satisfactory operation to be expected from the various motors under consideration. The author discusses the choice from 5 different motors with different ratios of gearing and different outputs, and shows how the choice is determined.

W. H. S.

874. *Wear of Tramcar Tyres.* **A. Norton.** (Engineer, 126. pp. 292–298, Oct. 4, 1918.)—It is difficult to correlate and assess the relative importance of all the "factors" influencing the wear of tramcar tyres, especially when the attempt is made on a worn tyre submitted for examination. The problem may be attacked in detail by collecting well-defined examples of defects or abnormal wear, the cause of which can be traced definitely. By way of example the "shelling" of tyre treads is discussed. Shelling might be due to a blow-hole below the surface of an ingot used for tyre-making, but blow-holes are not very common in such ingots, whereas shelling or splintering is very common, and more so now than formerly. It is reasonable to suppose that it is due to or promoted by running conditions. Investigations show that rails rolled originally to 1 in 20 are frequently worn to 1 in 6, so that when a new tyre, with a rim inclined at 1 in 21, is run on such a rail the load is carried either by the flanges or the outer edge of the tread, or both. The flange may be badly deformed and a fin or burr is sure to form quickly on the edge of the tread. The steel used in the tyre is hard (0·65 to 0·85 % carbon; 60 to 70 tons tensile strength); hence the effect of this cold-working is dangerous. The severe compressive stress on the inside surface of the burr—particularly in the corner—leads to cracks which extend across the tread of the tyre and ultimately cause a piece of metal to flake off. Though defective steel is sometimes responsible, shelling is due in 90 % of cases to burrs on the outer edge of tyres, due to running on rails which do not permit the load to be distributed uniformly over the tread of the tyre.

The angle of new or re-formed tyres should be approximately the same as that of the rails. Burrs should be removed as soon as noticed and the corner should be formed to a radius rather than to a chamfer. Accurately rolled tyres save machinery costs but wear worse than machined tyres. During each reheating from the ingot to the finished tyre the surface steel

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is decarburised. There is finally obtained practically a skin of wrought iron which wears badly and soon forms a burr. A Brinell test (undertaken with a view to pairing tyres for hardness as well as for size) gives unreliable results unless the decarburised envelope is first machined off. R. E. N.

ELECTRIC LAMPS AND LIGHTING.

875. *The Tungsten Arc.* **O. Kruh.** (Elektrot. u. Maschinenbau, 36. pp. 345–348, Aug. 4, 1918.)—The author reviews various methods that have been adopted for forming an arc between tungsten electrodes, in some cases one electrode being brought into contact with the other by means of an electromagnet and then withdrawn, in others a third, conical element being interposed by the same means between the electrodes to strike the arc. Subsequently ionisation methods, involving the heating of a rod composed of suitable alkali-earth oxides, are discussed. This leads to a description of the method employed in the Ediswan "Pointolite" lamp. The distribution of pressure in the arc is discussed, and it is remarked that the fall of pressure at the electrodes depends on the nature of the gaseous atmosphere, being least for argon and greatest for hydrogen.

The light from the tungsten arc is essentially whiter than that of gas-filled glow-lamps; the consumption is stated to be 0·4 watts per c.p. and the intrinsic brilliancy about 40 c.p. (Hefner) per mm.^{2}. The lamp is rich in actinic rays and the nature of the source lends itself to projection and ultra-microscopic work. J. S. D.

876. *The Foot-candle Meter.* **C. F. Sackwitz.** (Am. Illum. Eng. Soc., Trans. 13. pp. 292–296; Disc., 296–302, July, 1918.)—The term "foot-candle meter" is applied to a form of illumination-photometer which can be read by inspection, without its being necessary to manipulate the parts to obtain balance. The instrument is a variant of the type previously described by C. H. Sharp [Abs. 865 (1916)]. A small glow-lamp is mounted inside and at one end of a box with whitened interior. A photometric scale is let into one side of the box, and consists of a sheet of clear glass on which is mounted a strip of semi-opaque paper with holes punched in it at regular intervals, over which is superimposed a similar strip of thinner paper. When the lamp is lighted a series of discs of progressively diminishing brightness is seen and the balancing point can be read off by inspection. The range of the scale is from 0·5 to 25 candle-ft. A voltmeter and rheostat are provided to ensure the lamp working under constant electrical conditions. Some experiments with the photometer are described and it is suggested that an accuracy in the neighbourhood of 15 % may be expected. J. S. D.

877. *Report on Automobile Headlights.* (Am. Illum. Eng. Soc., Trans. 13. pp. 259 and 288; Disc., 288–291, July, 1918.)—The report is divided into five sections dealing respectively with (1) Introductory matter, (2) Requirements of vision, (3) Optical properties of headlights, (4) Practical headlighting, (5) Safety limitations. The Committee is concerned with (*a*) the designing of headlight systems, and (*b*) the framing of legislation on headlights; in this report only the principles are discussed. Full data are presented showing the relation between discrimination factor, threshold limit, glare limit and brightness. A compromise between requirements of drivers and pedestrians is necessary. Attention is drawn to the value of adequate road-illumination, especially at crossings. Diminution of glare may be effected by (1) special front glasses, (2) special caps and mirrors, and (3) devices for dimming and

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tilting headlamps. As regards confining the beam below the horizontal, the effect of irregularities in the roadway must be considered, but the tilting effect is here only momentary. Of more consequence is the tilting due to inequalities in the loading of the car, which may amount to several degrees. Lamps should be regulated for average loading. Under the head of safety limitations it is recommended :—(1) that the beam should be confined below a plane 42 in. above the road and parallel to it, measured 100 ft. ahead of the vehicle. (2) No scattered light should be tolerated which at 5 ft. above the road surface exceeds a certain c.p. Provisionally 500 c.p. 1° above the horizontal is suggested. (3) Minimum roadway illumination should be 0·001 candle-ft. (4) Minimum spread of the beam at distances of 50–100 ft. ahead of vehicle should not be less than 10 ft. in width. No recommendation is made as regards colour. A list of references to papers on headlights is appended. J. S. D.

878. *An Integrating Hemisphere.* **F. A. Benford, Jr.** (Am. Illum. Eng. Soc., Trans. 13. pp. 823–851, Aug., 1918.)—The use of the integrating sphere is subject to limitations arising from the errors introduced by the dimensions of the light source and the fact that paints used for the interior are never exactly diffusing. Thus the brightness may be 15 % low at grazing incidence. There has been a tendency to aim at greater accuracy by enlarging the dimensions of the sphere from 1 to 2 m. in diameter or more. But the author contends that greater accuracy can be obtained from a whitened hemisphere, which is specially adapted for testing focusing or projector units. The principles underlying the method, and the various sources of error, are discussed mathematically. Concentrating units, whose beam is confined within a small angle, may be placed without the hemisphere. With distributing units the axis of the source must lie in the plane of the opening. Experiments on hemispheres of 1 m. and 2 m. diameter are described. The following figures are presented for the accuracy attainable :—1-m. sphere, 2·9 % ; 2-m. sphere, 1·75 % ; 1-m. hemisphere, 0·78 % average error. The conclusion is drawn that the hemisphere-method leads to greater accuracy than if a sphere is used, besides being more convenient. J. S. D.

879. *Standard Specifications for Glow-lamps.* (Bureau of Standards, Circ. No. 13. [14 pp.] Washington, 1918.)—The specification is a revision of that originally framed in 1907 and modified at intervals up to Aug., 1915 (seventh edition). The 1915 edition is now supplemented by the inclusion of data relating to gas-filled lamps. The first sections deal with general specifications and relate to units employed, quantities tested, and particulars of lamp (class, size, type, etc.). Following this the requirements as to physical characteristics (absence of flaws in bulb, vacuum, bases, etc.) are given and the method of initial inspection and tests is described. Directions are then given as to requirements of life and candle-power maintenance and conditions of rejection based thereon. All the above is substantially similar to procedure laid down in previous specifications. Lamp schedules are divided into (A) tungsten lamps and (B) carbon multiple lamps. For vacuum tungsten lamps (110–125 volts) a useful life of 1000 hours (20 % drop in c.p.) is required, the specific consumption for the 10- to 100-watt types varying from 1·67 to 1·26 initial watts per mean sph. c.p. For 220–250-volt lamps special consumptions (1·65–1·89 watts per c.p.) are stated. For gas-filled lamps for multiple burning the same life is specified, but for the present a drop of 25 % of initial c.p. is allowed. The specific consumption for lamps from 75 to 1000 watts is tabu-

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lated and ranges from 1·09 to 0·70 initial watts per mean sph. c.p. Specific consumptions in terms of watts per mean horiz. c.p. are also given. J. S. D.

880. *Desirable Proportions of Local and General Lighting.* **F. C. Caldwell and W. M. Holmes.** (Am. Illum. Eng. Soc., Trans. 13. pp. 308–312; Disc., 313–322, Aug., 1918.)—The author endeavours to ascertain the proportions of general and local lighting preferred by most people by actual tests in a room 10½ ft. square. General illumination is available from lamps in wall-boxes and local lighting from a shaded light on a table. The walls could be either dark or light. Observers were asked to find by trial the desired proportions of the two methods of lighting, the relative values being then ascertained photometrically. The results are assembled in tabular form. With a light ceiling and dark walls, and with illumination on the work ranging from 2 to 6 candle-ft., the usual preference is for 40 % of local and 60 % general lighting. This ratio was apparently the same for men and women and was not materially affected by changing the walls to a light colour. With the above proportion the ratio of brightness of ceiling to that of working plane (white surface) was between 2·5 and 3. J. S. D.

881. *The Lighting of Printing Works.* **F. H. Bernhard.** (El. Rev., Chicago, 73. pp. 279–286, Aug. 24, 1918.)—In the introductory portion of the article the author summarises the advantages of good lighting in printing works, emphasising the necessity for quick and accurate work, and the serious nature of delays. The entire cost of lighting per man for a whole day is but a small fraction of a compositor's wages, and a case is mentioned where improved lighting conditions improved the efficiency of the work by 25 %. The general characteristics of good lighting are next discussed, importance being attached to (1) sufficient illumination and proper direction of light, (2) avoidance of glare, (3) uniform distribution and avoidance of sharp shadows, (4) general lighting, as preferable to local lighting. Photographs of typical installations are reproduced and a schedule of the intensity of illumination required for different processes in a printing works is given. Finally, attention is drawn to the importance of "artificial daylight" units for colour work. J. S. D.

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TELEGRAPHY AND TELEPHONY.

882. *Langmuir's Method for preparing the Three-electrode Vacuum Tube.* (Wireless Age, 6. p. 14, Oct., 1918.)—Describes in detail recent modifications of Langmuir's 3-electrode valve. The filament is straight, with a tension spring at one end, and is supported by means of a framework of glass or quartz, on which is wound closely the grid. Leads are brought out from both ends of the grid, and thus the fall of potential along it may be made the same as that along the filament. In some cases this is a decided advantage. The anode is strung in zigzag manner over hooks on four fork-shaped supports. The exhaustion and preparation of the electrodes by electron bombardment have previously been described [Abs. 596 (1918)]. A. W.

883. *Langmuir's Method of constructing Gas-free Electrodes for Vacuum Tubes.* (Wireless Age, 6. pp. 13-14, Oct., 1918.)—Langmuir has recently described a method whereby the anode of the vacuum tube consists of a coating of metal sprayed on the inside of the bulb by incandescing a refractory metallic conductor such as tungsten in a partial vacuum. To accomplish this the temperature must be sufficiently high actively to vaporise the refractory metal. This vaporised metal is deposited on the walls of the bulb as a hard, strongly adherent film, which even when so thin as to be transparent is a good electrical conductor, and capable of carrying relatively heavy currents. One 3-electrode tube made by Langmuir in this manner was capable of receiving anode currents of 100 milliamps. or more. Details are given of a 2-electrode and a 3-electrode tube, with diagrams. The preliminary exhaustion should reduce the pressure to 0·001 mm. or less. Two wires sealed into opposite sides of the tube provide contact to the film deposited inside. A. W.

884. *Contact Detectors in Radio Measurements.* **L. W. Austin.** (Washington Acad. Sci., J. 8. pp. 569–570, Oct. 19, 1918.)—On account of the difficulties experienced with various types of thermo-elements used in radio measurements, including vacuum thermo-elements and welded tellurium elements, these have been replaced in the U.S. Naval Radio Laboratory by a shunted contact detector circuit of a novel type. A contact detector is joined in series with a high-resistance galvanometer, which is shunted with a paper condenser K of 1 mfd. capacity. Across this system is joined a resistance R which may have any value from 0·1 to 100 ohms, and the oscillatory circuit to be dealt with is connected across the ends of the resistance. The greater part of the high-frequency current passes through the resistance, while a small portion is shunted through the condenser K and the detector. The direct current from the detector after passing through the galvanometer returns through R. On account of the high resistance of the detector, the total resistance of the detecting system is practically identical with R, as has been experimentally tested between 0·1 and 100 ohms. The sensibility of this arrangement is much greater than that of the best vacuum thermo-elements of equivalent resistance. In the case of most of the well-known detectors, the proportionality between deflection and current-square is excellent. Galena, while the most sensitive of any of the detectors tried,

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shows a slight deviation from the square law. For absolute current measurements the system must of course be calibrated by comparison with a known thermo-element at the time of experiment. A. W.

885. *Amplification Obtainable by the Heterodyne Method of Reception.* **G. W. O. Howe.** (Inst. Radio Eng., Proc. 6. pp. 275–284, Oct., 1918.)—Some difference of opinion appears to exist as to the max. amplification obtainable by the simple heterodyne method of receiving undamped signals. In this paper the author contrasts the Cohen theory that heterodyne amplification can be increased indefinitely by increasing the local current (using an ideal detector of unlimited current-carrying capacity) with the Liebowitz theory that the max. "true heterodyne amplification" is 4. Armstrong's results obtained with the auto-heterodyne appear to support the view put forward by Liebowitz [Abs. 408 (1917)]. It is shown by several different methods of considering detector and heterodyne action as compared with chopper detection of received energy, that if the detector gives an audibility current proportional to the received current, the max. amplification of audio power is 2·48, and does not increase indefinitely with the local current. With detectors giving an audibility current proportional to the square of the received current, *e.g.* ordinary contact detectors through a considerable range, the amplification may greatly exceed four, and its excess over four cannot be accounted for on the basis of "increased detector efficiency," since a steady polarising current will not produce the same increase. A. W.

886. *Oscillographic Study of a Howler Set.* **L. Pyle.** (Washington Univ. Studies, 6. Sci. Series No. 1, 1918. El. Rev. 83. p. 488, Nov. 8, 1918.)—A telephone transmitter capable of continuous operation at ½-amp. under an applied p.d. of 12 volts was placed in series with 8 fresh dry-cells and a fixed non-inductive resistance of 1 ohm, the resulting current also traversing the primary of a small induction coil whose vibrator was closed and secured. A head-type telephone receiver of 1000 ohms' resistance was connected to the secondary of the induction coil, which had a resistance also of 1000 ohms. When the mouthpiece of the transmitter was brought close to the diaphragm of the receiver, a musical note was emitted by the latter upon closing the primary circuit, or upon tapping the instrument if the primary current was already flowing. The pitch of the note depends on the nearness of the mutually excited diaphragms, upon the resistance of the receiver circuit, and upon the way in which the receiver happens to be connected to the secondary terminals. Oscillograph records were obtained of the currents in the receiver and transmitter circuits. The currents in the transmitter circuit are unidirectional, but exhibit marked variations, the minima being about 8 % of the maxima. The currents in the receiver circuit depart very largely from the sine form, and the maxima in one direction are about 30 % greater than those in the other direction. The frequencies are of the order of 1000 per sec. Records were also obtained of the motion of the receiver diaphragm. A. W.

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SCIENCE ABSTRACTS.

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1918.

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The numbers refer to Abstracts; if the letter A follows a number the Abstract will be found in Section A under that number

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In Properties of Engineering Materials:—Metallography, and Properties and Treatment of Metals Miscellaneous; Properties of Materials (excluding Metals).

In General Electrical Engineering:—Accessories and Appliances (electrical, excluding traction); Alternate- and Direct-current Research; Apparatus and Instruments (descriptive); Batteries (primary); Batteries (secondary); Electric Furnace; Electrochemistry (Industrial) and Industrial Chemistry; Equipment of Factories, Mines, Ships, &c.; Heating and Cooling; Insulation and Insulators; Measurements; Machine Tools, Cranes and Elevators, &c.; Magnetic Properties; Miscellaneous; Transporting and Conveying (including Gearing).

In Generators, Motors, and Transformers:—Alternators; Dynamos; Miscellaneous; Motors; Rectifiers; Transformers and Rotary Converters.

In Power Transmission, Traction, and Lighting:—Accessories and Appliances (traction); Automobiles (Electric); Cables, Conductors, and Wiring; Costs; Electricity and Traction Works (descriptive); Lamps (arc) and Arc Lighting; Lamps (incandescent) and Lighting by Glow-Lamps; Miscellaneous; Power Transmission and Distribution; Rolling Stock; Switching and Controlling; Track Construction and Materials; Traction (electric, by accumulators); Traction (excluding accumulator traction and descriptions of power stations); Traction (mechanical).

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CLASSIFIED ACCORDING AS THEY ARE DRIVEN BY (1) STEAM, (2) WATER-POWER, OR (3) GAS-ENGINES.

Special Features are denoted by letters in brackets. Thus:—(Al) *signifies Aluminium Conductors;* (B) *Battery;* (D) *Destructor;* (GF) *Gaseous Fuel;* (LF) *Liquid Fuel;* (MS) *Mechanical Stoker;* (S) *Superheater;* (SC) *Surface Contact System;* (ST) *Steam Turbine. Voltages above* 10,000 *are indicated.*

STEAM-DRIVEN.

Albany, N.Y., 208 ...(12,000 volts) (ST) (S)
Appleton, Wis., 373 .....(66,000 volts)
Buenos Aires, 371 .....(ST) (S) (LF) (B)
Chicago (North-west Station), 372
Columbus, Ohio, 590 (13,200 volts) (ST) (S)
Fort Wayne-Decatur Railway, 77 (d.c. 1,200 volts)
Gothenburg, 384 .....(ST)
Joliet, Ill., 139 ... (33,000 volts) (ST) (MS)
Langenthal-Melchnau Railway, 367
Milwaukee (Rockwell Manufacturing Co.), 75 .....(S)
Montreal (Hochelaga Plant), 813 (13,200 volts) (MS)
Pennsylvania Railroad, 366, 525
Rivermines, Mo. (St. Joseph Lead Mine), 209 .....(ST) (MS)
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Hiram Falls (Cumberland County Power Co., Portland, Me.), 74 ...(66,000 volts)
Lake Coleridge, N.Z., 450...(66,000 volts.)
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Savona-Ceva Railway, 212
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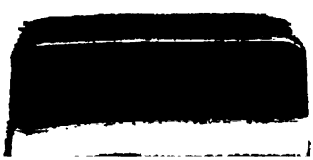

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